MACHINERY.
May, 1907.

ENGINEERING SOCIETIES BUILDING.

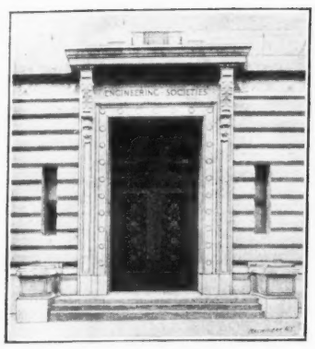

Fig. 1. Main Entrance.

ON April 16 and 17 an event occurred of much interest to the engineering fraternity of America, it being the dedication, with appropriate and impressive ceremonies, of the new Engineering Societies building in New York City. This magnificent structure is the property of the three founder societies, namely, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Institute of Mining Engineers, and is one result of a $1,500,000 gift made by Mr. Andrew Carnegie to promote "cooperation among engineers." Thus will a great ambition be realized on the part of the leading members of the chief engineering societies, all having their headquarters in New York, it having been their earnest desire for the past twenty years to bring together under one roof the various libraries of these societies where the accumulation of books will be convenient for reference to all. Also the concentration of headquarters will avoid the economic waste of having a number of large auditoriums provided and used, at most, only four or five days in the year. Other advantages of cooperation were foreseen, which will be mentioned later. Of the $1,500,000 gift, $450,000 went for the construction of the Engineers' Club building on 40th Street between Fifth and Sixth Avenue, and $1,050,000 for the Engineering Societies structure on 39th Street. The two buildings are on adjoining lots and communication is provided between them on the ground level and by a flying bridge between the ninth floor of the Engineering Societies building and the tenth floor of the Engineers' Club building.

Location and Design.

The frontage of the site of the new building covers five city lots, Nos. 29 to 33, the total front being 125 feet. The land cost the three societies $540,000, one-third being payable by each society. The depth of the lots is 110 feet, and the building itself is 115 feet long and 90 feet in depth. The building laws of New York City require that only 85 per cent of the lot area shall be occupied by the structure on it. Advantage was taken of this limitation to give the building a monumental appearance and to provide a driveway clear around it. One entrance to this driveway is indicated by the opening on the far side of the building in Fig. 3, the other being outside in the foreground.

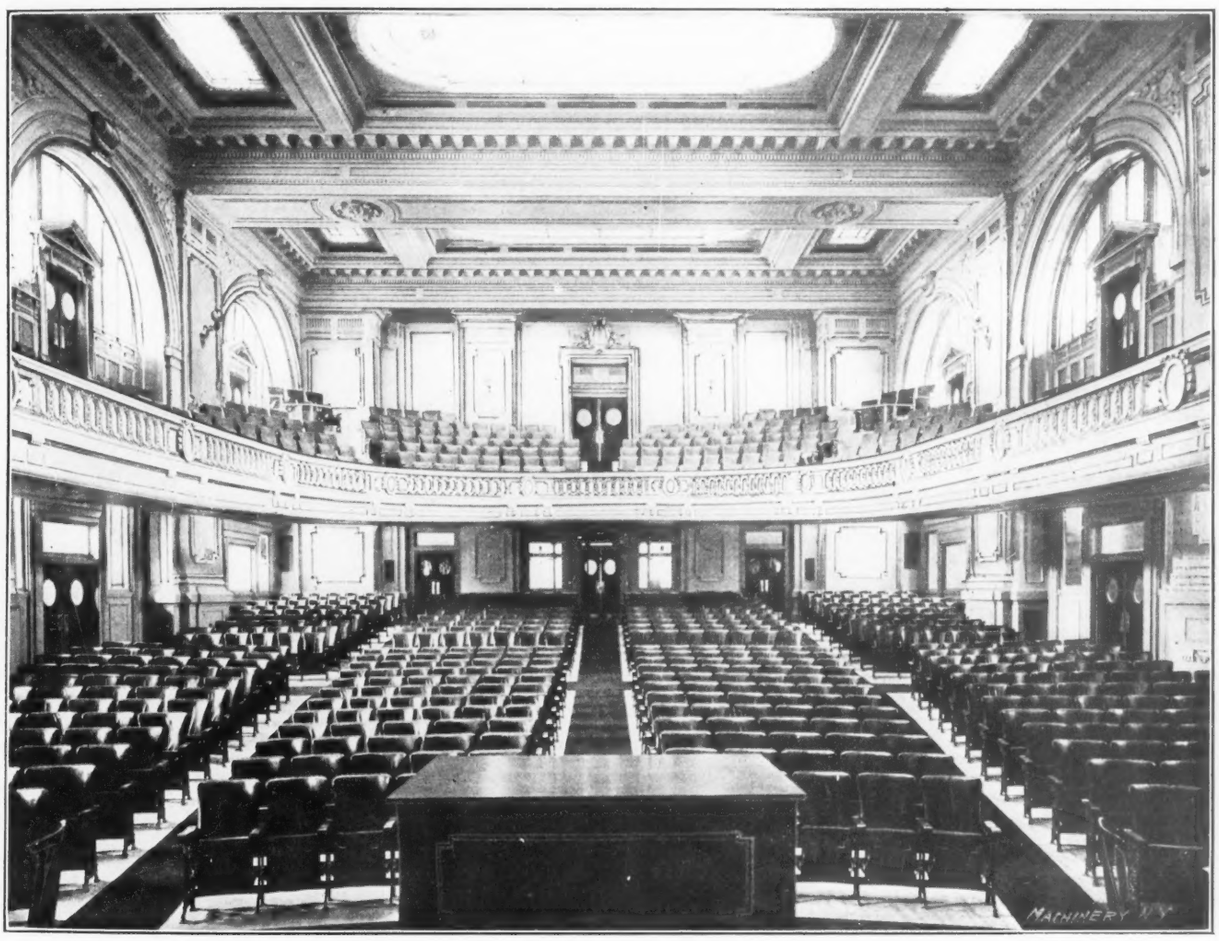

Fig. 2. Main Auditorium from Stage.

The structure was designed in the French style by architects Messrs. Herbert D. Hale, of Boston, and Henry G. Morse, of New York as associate. Their plans were selected from a mixed competition in which twenty-six designs were entered, all anonymously. It rises 13½ stories from the sidewalk to a height of 218 feet 6½ inches, and presents a most pleasing and

impressive appearance. The exterior is built of limestone up to the auditorium floor, and of gray mottled brick and terra-cotta above. Inasmuch as the lower portion is devoted to auditoriums, the middle section to offices, and the upper part to the library, an effort has been made to accentuate these separate parts of the building, as will be seen by referring to the illustration of the architect's perspective drawing that appeared in the January, 1906, and January, 1907, issues.

All the steel work in the building is covered with semi-porous terra-cotta, and the columns are grouted with concrete.

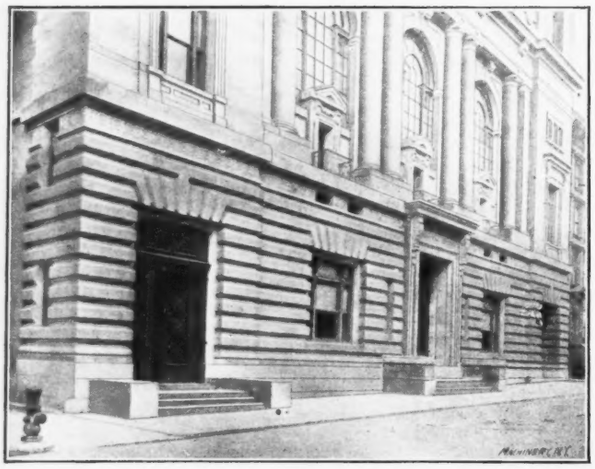

Fig. 3. Front of Engineering Societies Building.

The floors are built with terra-cotta 6-inch segmental arch construction overlaid with 5 inches of cinder concrete. All exterior walls are furred with 2-inch terra-cotta block to prevent sweating. The foundations were carried down to bed rock and the building is carried on forty-six concrete piers, running from 27 to 67 feet below the curb line. The total weight of the steel employed in the building construction was 2,650 tons.

The woodwork in the building has been reduced to minimum. The large windows are built of cast iron and the other windows of wood covered with kalamined iron. All the woodwork including floors, sleepers, trim, etc., has been made fireproof and in general the effort has been made to reduce the fire risk as much as possible. This is indicated by the very

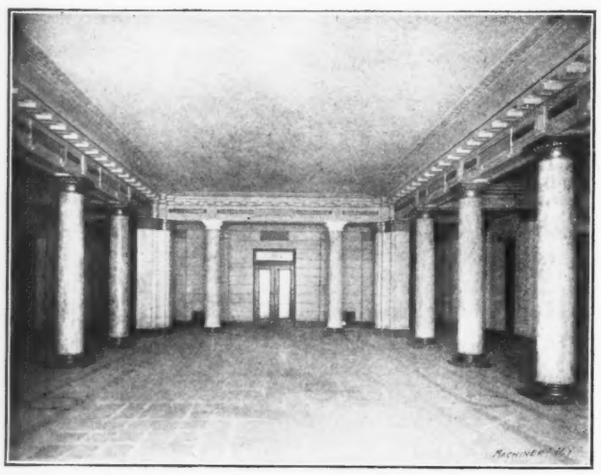

Fig. 4. Main Entrance Hall.

low insurance rate of 15 cents per $100, which is the premium paid. Additional precaution against fire has been made by placing an 8,000-gallon tank on the roof, fed by two electric pumps, with a stand-pipe on each end of the building.

Heating and Ventilation.

The basement is occupied in part by the boiler room, engine room and coal storage. The building does not have an isolated light and power plant, however, all electrical energy for light and power being taken at present from the mains of the New York Edison Co. The steam plant is employed for heating and ventilating purposes only. Steam is generated at low pressure by three Babcock & Wilcox boilers, having 5,226 square feet heating surface. These boilers are high-pressure boilers and may be used for generating steam for power should it ever be deemed advisable to put in an isolated power plant for the building. To make future installation simple, the engine room and main pipe lines have been provided.

The heating of the building is accomplished by low-pressure steam circulating through radiators beneath the windows. This method is claimed to be an economical way of heating and to be effective in counteracting the down draft from the windows. All the radiators are controlled automatically by the Johnson system. No blower or mechanical means are required for heating the rooms, the extensive blower system installed being for ventilation solely. The ventilating is independent of the heating system, for while in the winter months the building must be heated twenty-four hours per day the ventilating system is required only when the halls and rooms are occupied. This separation of heating and ventilation is therefore economical and simple of operation. The ventilation is effected by four electrically-driven Sturtevant blowers erected in the basement. Air is exhausted from the auditoriums, basement and other rooms throughout the building by means of four electrically-driven Blackman exhaust fans located in fan houses on the roof. One hundred thousand cubic feet per minute represents the total air supply when the blowers are all operated at once.

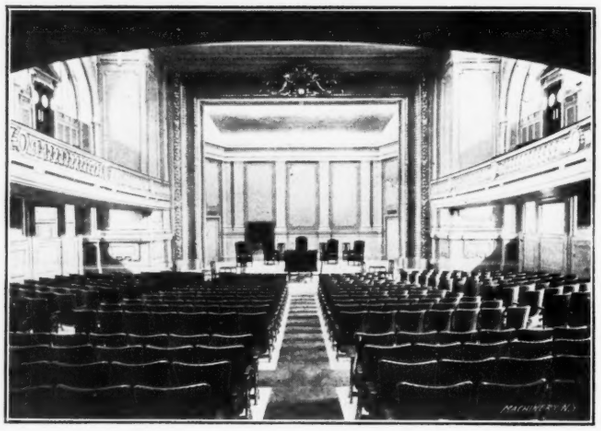

Fig. 5. Main Auditorium, looking toward Stage.

Illumination.

Much attention has been given to the matter of illumination of the offices, halls, and auditoriums. The central space in the entrance hall is lighted by means of individual lamps placed in recesses and concealed by panes of ground glass in the ceiling, at the sides of the rectangle formed by the columns around the large central area. The glass diffuses the light and reduces glare. In addition large central crystal ball "metalized filament" lamps of 50 to 250 watts are provided. The lighting of the auditorium is probably the most interesting feature of illumination in the building. A space of about 15 inches between the ceiling of the auditorium and beams of the floor above was provided, and glass septums substituted for the usual plaster panels in the ceiling. In this space the electric lamps are stationed. The result obtained is very satisfactory, the general effect being both soft and pleasing, resembling sunlight passing through glass. In the assembly and lecture rooms the cove method was adopted, the lamps being concealed on the sides and ends and throwing their light on the ceiling from where it is reflected into the room. The general illumination of the library is obtained by means of lamps placed above the glass ceiling skylight on the plan similar to that used in the auditorium. A special kind of glass has been used in both cases to reduce the intrinsic brilliancy or glare, at the same time having a minimum of absorptive value.

Auditorium.

The main auditorium extends up through two floors, and with its gallery will seat about 1,000 persons. It had to be

arranged for the general meeting of the societies at which the speaking is from the floor as well as from the platform, and for this reason the requirements are unusual and difficult to meet. The acoustic properties are remarkably good, however, and it may be safely said that no other assembly room in New York City is more finely equipped or better suited to its purpose than this. The illustration, Fig. 2, gives some idea of its beautiful design and general scheme of decoration.

Lecture Rooms.

The next two floors above the main auditorium are devoted entirely to lecture rooms of which there are seven. Two assembly rooms 51 x 66 feet and 29 x 66 feet occupy the larger part of the fifth floor. Two smaller rooms on this floor, 16 x 22 feet and 18 x 19 feet can be used separately or as annexes. The sixth floor is divided into lecture rooms of somewhat smaller dimensions than those on the floor below. In this way there are provided meeting rooms suitable for assemblages of 1,000 down to 100.

Office Floors.

The seventh and eighth floors of the building have been reserved for associations or societies that have engineering or some department of science as their principal object. For these organizations the building affords office areas of varying sizes from one room up with the common facilities of a lecture room, library, and other accessories. Among the societies

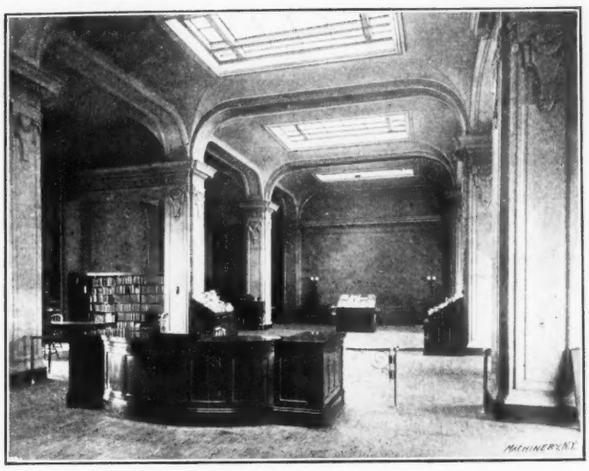

Fig. 6. Section of Library.

which have availed themselves of these offices are the Society of Naval Architects and Marine Engineers, The Society of Heating and Ventilating Engineers, National Electric Light Association, Society of Chemical Engineers, New York Electrical Society, Association of Edison's Illuminating Companies, American Street and Interurban Railway Association. These societies yield an income for the offices occupied to the three founder societies, and thus contribute to the general maintenance.

Founder Societies' Floors.

Each of the founder societies occupies a floor laid out in accordance with its own plans. The American Institute of Mining Engineers has the ninth floor, the American Institute of Electrical Engineers the tenth floor, and the American Society of Mechanical Engineers the eleventh floor. The twelfth and thirteenth floors are reserved for the libraries of the three founder societies and for such other collections of engineering literature as may be added. The twelfth floor has been devoted to the book stacks, but at the present time the main library is also equipped with one tier of stacks with provision for a gallery tier later. The location of the library at the top of this fine building, free from noise and dust, makes it ideal for the student and others engaged in research. Its proximity to the new Public Library makes the location still more advantageous to the engineer, and will help to make it an important center for the diffusion of useful knowledge. The engineering fraternity of this country are to be congratulated on this magnificent building and equipment which have been made possible by the gift.

PROMOTING INDUSTRIAL EDUCATION.

ARTHUR D. DEAN.

Arthur D. Dean.

Once upon a time there was a man who thought that he could do much good in the world by establishing industrial education for the workers. With this aim in mind he set out to inquire what people thought of his idea and, with their help, to discover some tangible way of carrying out his scheme. In his quest he found that every manufacturer was crying for more skilled labor and more efficient service; that every worker was praying, sometimes even fighting, for shorter hours and higher wages. His discoveries, while not very illuminating, led him to say to himself, "I have the remedy for the present discontent of employers and laborers. The manufacturers and the workers each have selfish desires. As a result of education for industrial workers these desires will be gratified. My scheme will solve an important problem of labor and capital."

The Worker.

With this hopeful conviction he carried his message to the workers in the form of an invitation: "Come into my evening classes and learn more about your trade." The first reply rather amazed him. "What's the use," the young worker said, "when I already get the highest scale of wages and fixed by the union at that?"

The worker at the next bench listened to his plea with a quizzical expression and replied, "I join a class in mechanical drawing? What's the use of my knowing about drawing, when I have jigs and fixtures with which to work, every hole already laid out, and all I have to do is to turn this lever and shift that belt?"

To his third invitation, with the added argument that through education he could become a foreman, the next youth answered, "I a foreman! Well I guess not! I can earn nearly as much as that fellow already and don't have any of his responsibility either."

"Must I give up?" the educator said to himself. "No, I will try the office force. There at least are some young men who want to understand the processes of production that they may have the broad view of the business so necessary to the successful man in these days." So he accosted a dapper, bright-looking youth and called his attention to the benefits of industrial education. In no uncertain tone came the reply, "My father is a mechanic, and he tells me to stick to the office work. It's cleaner. It doesn't soil my hands, and besides, who wants to be a mechanic to-day anyhow?"

The General Manager.

With spirits somewhat dampened at the reception of his invitation by the people whom his work was intended to benefit, the enthusiast went into the office of the general manager. Here his reception was cordial. "Industrial education is just

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ARTHUR D. DEAN was the first graduate of the Rindge Manual Training School in Cambridge, and this school was the first of its kind in New England. Here Mr. Dean acquired the belief that industrial education was a matter of the greatest importance, and he decided to make its study his life work. Following his graduation he took a course in the Massachusetts Institute of Technology, and graduated from the electrical engineering course in 1895. He introduced manual training in the grammar course at Portland, Maine, and then became supervisor of manual training in the high and grammar schools at Malden, Mass., from where he was called to Springfield, Mass., to become director of shop work and to assist in the organization of the technical high school under the superintendent, Thomas M. Balliet. Here the first evening trade school in America was established in connection with a day technical school, and Mr. Dean was put in charge of the engineering and mathematical courses. He left this position after eight years of service to become special supervisor of industrial education for the State Executive Committee of Massachusetts and Rhode Island. In 1902 he went to Porto Rico for the United States Government to investigate industrial conditions on the island with the view of establishing industrial schools. His present work is to go into cities which have no special education to fit their special industries and to establish trade schools to meet the needs of industrial workers. His work covers schools for plumbing, textiles, shoemaking, jewelry design, automobile construction, machine work and electrical work.

what we need. We want our young men to have this education. We are short of good under-foremen, men who can take simple responsibility. The promotion of industrial education is a great work. You have my hearty cooperation." Continuing, the general manager said, "We will take every young man who becomes proficient in your classes and give him a good position. I congratulate you on your endeavors."

With this encouraging word the student of education left the office stimulated to consider the difficulties in his path and to devise some means of conquering them. "Evidently something is wrong with my procedure," he soliloquized. "I have something which is wanted by the manufacturer, which is needed by the workers and yet which will never succeed until I enlist the interest of the men who are to receive the education as well as that of the manufacturers who need intelligent service. I must go about this promoting work in a more systematic manner. Perhaps I ought to consult the academician and the union leader as well as the two factions directly concerned—the manufacturer and the worker."

The Professor.

The next day he accosted his friend, Professor Smith, on the street and abruptly asked him, "How am I to promote industrial education?" The learned gentleman, after a moment of thought, for the wise man never commits himself with ready definiteness, replied, "There are three great factors to be considered in this matter. You must consider the interests of the union, and of the manufacturer; and the feasibility of working in conjunction with the existing public school system. You must not expect to do anything worth while until you have the cooperation of these various interests. You see, my friend, nothing can be accomplished in these days unless you consider the interests of all parties concerned. You must get the manufacturers on your side and educate them to take an unselfish point of view; you must consult the labor leader in order to enlist his support, and thus gain the confidence of the working men; and finally you must adapt your scheme to fit in with the methods and purposes of the public schools."

The Labor Leader.

With these words of scholastic counsel ringing in his ears, the man with the project went to the headquarters of the local union. He found the chief spokesman for the sons of toil sitting at his desk.

"Good morning, Mr. Labor Leader, I want to interest you in a school proposition which will benefit the industrial workers of the city."

"What kind of a school is it?" asked the leader. "One of those trade schools which puts our men out of business?"

"That's where you are mistaken. Such a result would hardly follow from the trade school, it seems to me," replied the educator.

Then the labor leader waxed warm as he said, "These schools are raising the very devil with our trade. They turn out a half-baked lot of scabs who go to work at less wages and replace old, tried mechanics. Besides, you can't teach a trade in school. The place to teach a trade is in the shop. It's the only place. Every trade school in this country has been a failure."

"It strikes me," said the educator, "that your statements are somewhat inconsistent. If the schools are failures, how can they have injured your trade? And if the graduates of these schools are really 'half-baked' as you say they are, how can the manufacturers be so blind as to retain their services? By the way, it occurs to me that possibly you can suggest the names of these schools to me, as I should like to visit some of them and study their methods."

After a moment's hesitation the labor leader was obliged to acknowledge that he had never visited a trade school, nor could he name any in the country. In closing the interview he definitely stated that unions were opposed to trade schools, and if his visitor started a school he would not be able to get a union man to teach in it, as the rules of the organization did not permit it except by the unanimous vote of the entire council.

The promoter of industrial schools attempted to re-open the conversation by saying, "But, my dear sir, I am only attempting to introduce evening school work for your industrial workers. They will get better wages and better positions through education which fits in with their daily work. I have already enlisted the support of the manufacturers, and I thought that it would only be fair to come around and see you and get, if possible, some labor union representative on the board of government of the industrial school.

"That's just what I thought," replied the leader. "This is a scheme of the manufacturers to train a lot of fellows to take the places of my men at less pay. I am familiar with the game."

"You misunderstand me. I distinctly said that these industrial workers would be getting an education which would fit in with their daily work, a statement which implies that I expect only men already engaged at a trade, the machine trade, for instance, to be allowed to take machine practice in my night school."

"Oh! If that is the case the Union will gladly assist you. We shall be pleased to be represented on your board of government, and I will call the attention of our men to your school."

Our friend left in a most happy frame of mind. At last he had won labor to his support.

The Manufacturer.

Little thinking of the compromising position he had taken with the union leader, he entered the office of the manufacturer. The purpose of the visit explained, the greeting of the gentleman of the inner office was most cordial. He closely questioned regarding the proposed methods of organizing, the courses of study, the time required, the subjects taught, and the probable caliber of the teaching force. Then he thought a while and finally said, "Very good. Really your plan is excellent at every point; but why do you limit such a good school to those already engaged in the trade? It seems to me that you are running, so to speak, a 'closed shop school.' Surely educational opportunity should be for all. Are you not limiting opportunity? Why not encourage boys out of work and ambitious boys who are dissatisfied with their present jobs to come in and learn one of the trades which you are going to teach?"

Replying to this astute man, the educator said, "It is impractical to teach a boy a trade in the evening if he is inexperienced at any branch of that trade; for (unless he has had some previous training) the school can hardly do enough with him to make it worth his while. My theory of evening school work is that it should merely supplement the day shop work and not attempt to teach the whole of a trade."

"That's all right in theory, perhaps, but I am not a theorist, I am a practical man. Now I need machine hands. I cannot get them fast enough. The union has so fixed things in this shop that I cannot move without asking their permission. Now I will tell you what I will do. I will subscribe to the support of your school if you will agree to take in anyone who applies. Otherwise, not one red cent."

The bang of the fist on the desk settled the interview, and in a different frame of mind from that of his earlier enthusiasm, the promoter of evening schools for working men went out of the factory door.

The School Superintendent.

The educator next visited the superintendent of schools. Here at last he believed he would find a man who would be in thorough sympathy with his plan, a man who would take a broad view of the situation; one who would be able, through his years of experience, to assist him materially. He outlined his scheme in detail. Much to his astonishment, the superintendent said, "The function of the public school is to fit boys to be good citizens. The schools aim to create a general culture through the study of history, language, mathematics, etc. Their purpose is purely educational. They are engaged in preparing for true citizenship."

"But, my dear sir, does not training for citizenship involve proper training for one's daily work? It seems to me that a man is more self-respecting, more capable of voting intelligently, when he has an economic hold on modern industrial

life; that to educate a man so that he can, through more intelligent service, earn more money and therefore have a better home, more wholesome recreation, more financial independence, means that he will make a better citizen."

"Well, perhaps you are right," replied the pedagogue, "but your ideas are too advanced for this time. You must remember that taxes are high, new school buildings are needed every year, that no city has yet tried your scheme, so that no one knows whether it is practical or not."

After a moment's pause our promoter said, "I do not see it that way. If you had industrial schools which trained young men so that they became more efficient mechanics, then your industries could produce a higher grade of goods, a result which would mean that more money would come into the city. As the workers would get a good share of this additional money this gain would increase the retail store trade. You certainly know that nowadays labor receives a very large proportion of the market value of a product. As a consequence of the general raising of wages, better houses would be built, and the taxable property would increase. Besides, this progressive city might as well be the first one to make the experiment of adapting education more to the needs of modern industry and its workers."

But, alas, the man who knew the actual needs of life and who kept in touch with progressive industrialism was speaking a tongue not understood by the school man who had lived the life of a scholastic monk. The interview closed with this final word of the school superintendent, "The teaching of a trade is not the proper function of the public schools."

The Line of Least Resistance.

The promoter had certainly done his full duty. The instruction of the academician had been obeyed. There had been interviews with manufacturer, school superintendent, labor leader and workman. Meditating on the difference of points of view and the expression of class and professional prejudice, he said to himself, "I am endeavoring to promote something, the product of which every manufacturer acknowledges he needs, which would be of great benefit to every worker if he knew enough or had ambition enough to try it, and yet I am hampered by the narrow point of view of the labor leader, the blindness of the young workers who will not rise to their opportunities, and the short-sightedness of the pedagogue. It seems to me that the manufacturer's point of view ought to command my most thoughtful consideration. He is a man who has done things in the world; who is least hindered by prejudice, for he knows what he wants. He has risen from the ranks and is therefore progressive. He is direct, keen, and practical. Does he not, after all, express the sentiment nearest the truth when he pleads that education be made the open door of opportunity? After all, many of our present educational activities now under public auspices started under private enterprise, and why not in this new movement enlist the interest of such men as the manufacturer represents, trusting that as the school demonstrates its value to the community that the publicist, the school man and the representative of organized labor will finally contribute by personal service to its full development?"

Final Success.

To make a long story short, the promoter of industrial training established his school, obtaining the money for the building and equipment from public spirited men interested in the youth of the land and from the manufacturers who wanted the product—trained young men. The students paid a tuition fee which materially assisted in paying the running expenses of the school. At the beginning only a few young men, those with ambition and possessing the vision and the significance of the Door of Opportunity, enrolled in the classes. Any young man, whether he was in the trade or not, had the opportunity of attending the evening school and learning a trade. If he did not learn all of it in one season he came again until he completed the course. The decision to open the door to all, in opposition to the counsel of the labor leader, cost the promoter of the school the support of the unions, but the withdrawal did not injure the cause, as young men who wanted to learn came despite hostility. The graduates readily obtained increased wages and better positions through the training received. Eventually the good reports of the school reached the ears of the less ambitious fellows who stood aloof from the school in its early history, and they hastened to join the classes.

It was not long before the school became popular to a large degree. The academician never quite understood how the success came about, but he soon gave his wondering approval. The labor leader finally had the scales removed from his eyes when he saw that the school turned out mechanics who simply filled the places created by the ever-increasing demands of modern industry. Best of all, the workers themselves pointed with ever-increasing pride to the school as a vital part of an educational scheme which was inaugurated primarily to benefit them.

Popular sentiment became so strong that the school superintendent was forced to accede to the demands of modern life, and after careful study, urged on by a reconstructed school board composed of progressive business men who saw the needs of the future, he recommended that the municipality erect a building devoted to teaching the trades typical of the industrial environment, equipped with modern machinery, and engage teachers having a practical knowledge of the needs of industrialism. It is sufficient to add that this school became a leading and most popular school, that it served well the industrial interests of the vicinity, and that the dream of the promoter of education for industrial workers became a realization.

* * *

MECHANICS AND GENTLEMEN.

The editor of *Engineering*, London, recently had some very sensible things to say about an English institution known as "Premium Apprenticeship." The premium apprentice, be it understood, is a "young gentleman whose parents pay a considerable sum for permission for him to wander from department to department," presumably with his hands in his pockets, and his mind intent on gaining by observation such information as he may without surrendering his dignity. In the next issue of the journal referred to, one of these young men takes the editor severely to task for his good sense, relieving himself of the following remarks: "I have always held the strong opinion that the young man to encourage and extend help to *is* the premium pupil. He is usually the son of well educated parents and possesses a brain far above the average mechanic, and one which is very receptive and intelligent. * * * The leading men in all other professional walks of life are not drawn from the working class, but are gentlemen of superior education and are regarded and treated as such. Why should they not be in the engineering profession?"

As an offset to the sentiments quoted above (which do not need comment on our part) it is a pleasure to recall a quotation from an address delivered by Mr. Fred W. Taylor some months ago at the dedication of the University of Pennsylvania. He was pleading for a real honest shop experience for engineering students, preferably before entering college, or for a period of six months or more taken out of the middle of the college course. He said, "The student does not learn at college that on the whole the ordinary mechanics, and even poorly educated workmen, are naturally about as smart as he is, and that the best way to rise above them lies in getting his mind more thoroughly trained than theirs, and in learning things they do not know. All of this should be taught him through contact with working men."

It is scarcely fair, however, to place these two quotations in contrast as we have done, since one of them was written by a young man who will probably know more some time, while the other represents the conclusions of a man of wide experience and well-known ability. Nevertheless it is pleasant to remember that the idea that Mr. Taylor expresses is probably more widely believed and more thoroughly understood in America than in any other country in the world.

* * *

The classic crossing sign: "Railroad Crossing—Stop, Look and Listen," composed by Judge Paxon, is said to have cost the railway company $6,000, or $1,000 a word.

FUNDAMENTAL IDEAS ON THE STRENGTH OF BEAMS.—2.

JOHN D. ADAMS.

Neutral Axis Passes through the Center of Gravity.

We have now to see why the neutral axis always passes through the center of gravity, irrespective of the shape of the section. Referring to Fig. 5, let us imagine that the section is divided into a very large number of very small areas, such as a_1, a_2, a_3, etc., at distances from the neutral axis of y_1, y_2, y_3, etc., respectively. Now we have just seen that the stress per square inch at any point is $\frac{fy}{Y}$, therefore the total stress in area a_1 is $\frac{f a_1 y_1}{Y}$. Since the total tensile stress Q is the sum of

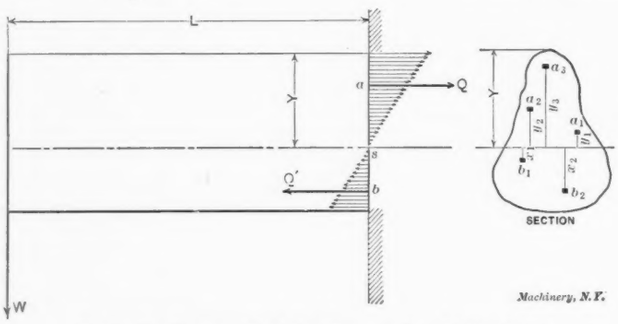


Fig. 5. The Nature of Resisting Moments in a Loaded Beam.

the stresses in these small areas we have:

$$Q = \frac{f a_1 y_1}{Y} + \frac{f a_2 y_2}{Y} + \frac{f a_3 y_3}{Y} + \ldots., \text{ etc.}$$

And since $\frac{f}{Y}$ is a constant and known quantity, we may write this sum:

$$Q = \frac{f}{Y}(a_1 y_1 + a_2 y_2 + a_3 y_3 + \ldots., \text{ etc.})$$

Similarly

$$Q' = \frac{f}{Y}(b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots., \text{ etc.}),$$

where b and x refer to small areas and their distances on the compression side. But since the total compression Q' equals

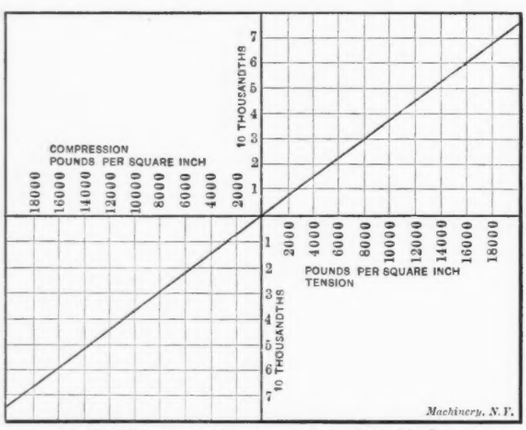


Fig. 6. Diagram for Representation of Hook's Law.

the total tension Q, by equation 1 (March issue), we immediately see that

$$a_1 y_1 + a_2 y_2 + a_3 y_3 + \ldots. = b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots.$$

Let us now imagine this section cut out from a piece of sheet metal, a square inch of which would weigh one ounce, and placed across a knife edge along the neutral axis. The weight of any area, a, would be a ounces, and the moment of a would be $a\,y$, and for the whole moment on this side of the line we would have $a_1 y_1 + a_2 y_2 + a_3 y_3 + \ldots$ etc. Similarly, for the moment on the other side of the knife edge, we have $b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots$ etc. But we have already seen that these two expressions are equal, when the dividing line is the neutral axis; therefore, these two moments are equal and the section must balance on this line. Hence, the neutral axis passes through the center of gravity.

If we stop and think for a moment, we can see without any figuring why this should be so. The value of any small area, a, as regards tension or compression, depends upon the stress at that point, and therefore (equation 2) upon its distance from the neutral axis. On the other hand, the moment of any small area, a, of a thin plate balancing on a knife edge, depends upon its distance from a line through the center of gravity. Therefore, if the sums of the elementary tension and compression forces are equal (equation 1), the sums of the moments produced by gravity must also be equal around this same axis.

Significance of the Moment of Inertia.

By equation 2 we know what the stress is in any fiber, and now that we know where the neutral axis is located, we may find the moment of these various stretched and compressed fibers around the neutral axis, thus determining the ability of the beam to resist another bending. Referring to Fig. 7, we see that the fibers which originally lay between the two parallel planes $K\,L$ and $N\,O$ now lie between $K\,L$ and $N_1\,O_1$, the point S on the neutral axis remaining stationary. The load W, having a leverage $H\,S$ on the point S, produces a moment or turning effect around S, which is counterbalanced by the moments around S of Q and Q', which represent the sums of the tensile and compressive forces, respectively. Since the beam is in equilibrium, we can equate the moment produced by the load, having a leverage equal to the length of the beam, with the sum of the tensile and compressive moments. The sum is called the moment of resistance of the section. By equation 2 we have the stress per square inch in any fiber at a distance y from the neutral axis $\frac{f\,y}{Y}$, so if we consider any small area a, we have the following equation:

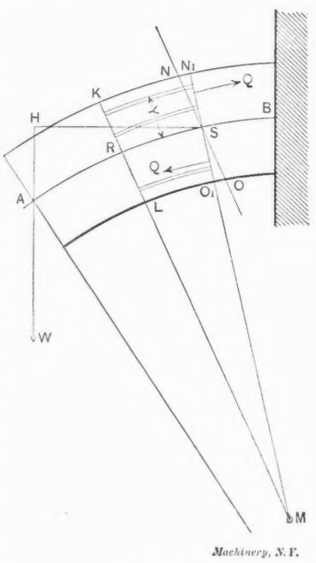


Fig. 7.

$$\text{Stress} = \frac{f\,a\,y}{Y}. \qquad (3)$$

This stress has a leverage of y on the point S, and therefore the moment of this element a is $\frac{f\,a\,y^2}{Y}$, and for the whole section we may write, since $\frac{f}{Y}$ is a constant and known quantity:

$$\text{Total moment around } S = \frac{f}{Y}(a_1 y_1^2 + a_2 y_2^2 + a_3 y_3^2 + \ldots.).$$

This sum, *viz.*, $(a_1 y_1^2 + a_2 y_2^2 + a_3 y_3^2 + \ldots.)$, for any section is called the "moment of inertia" of that section, and is used in this connection, not that inertia or motion has anything to do with the strength of a beam, but merely because of a mathematical similarity. If the section of a certain beam were cut out of a flat plate and whirled around its neutral axis, the expression, *viz.*, $(a_1 y_1^2 + a_2 y_2^2 + a_3 y_3^2 + \ldots.)$ would be a measure of the energy possessed by this rotating plate and is called the moment of inertia of that section. Many of these values, applying to a great variety of sections, have already been figured out. It is not within the scope of this article to enter into the mathematics of inertia, but some idea can be had by the approximate method shown in Fig. 8, where we divide a section into a number of equal parts and multiply the area of each part by the square of its distance

from the neutral axis. Values for any ordinary section can generally be found in the standard mechanical handbooks and are usually represented by the symbol "*I*." Substituting this in the above formula, we have:

$$\text{Moment of resistance } R = \frac{f I}{Y}. \qquad (4)$$

Where f is the maximum stress in pounds per square inch, and Y is the number of inches the extreme fiber is from the neutral axis, the moment or result will be in inch-pounds.

To illustrate the use of this formula, let us suppose that we have a floor beam composed of two 4 x 12 pine timbers, placed side by side and on edge, 12 feet between supports. We wish to place a chain hoist at the center of this span and hoist a motor weighing 3 tons. Will the beam stand it?

The moment of inertia for a rectangle is: $\frac{\text{breadth} \times \text{depth}^3}{12}$

$$= \frac{8 \times 12 \times 12 \times 12}{12} = 1{,}152 = I.$$

If we take $f = 1{,}200$ pounds per square inch, which ought to be safe for good pine, we have: $\text{Moment} = \frac{f I}{Y} = 1{,}200 \times \frac{1{,}152}{6} = 230{,}400$ inch-pounds.

The bending moment of a centrally loaded beam is $\frac{L W}{4} = \frac{144 \text{ inches} \times 6{,}000 \text{ pounds}}{4} = 216{,}000$ inch-pounds.

Hence, we may conclude that it would be quite safe to hoist this load.

Laws of Bending True only within the Elastic Limit.

Let us now consider the practical limitations of this formula. If we take a rectangular bar of iron of known tensile strength and determine its moment of resistance by equation 4, and then actually break it by bending, we will find that it will take a great deal more to break it than we had at first estimated. We must therefore explain this seeming discrepancy and determine to what extent the formula is practical.

The very basis of all of the foregoing is Hook's law, as illustrated in Fig. 6. If a piece of wrought iron, for instance, is placed in a testing machine and stretched until rupture occurs, and a record be kept at frequent intervals of the force applied and the amount of stretch produced, it will be found that at first the stretch and force are directly proportional, as shown in Fig. 6, but before breaking occurs, the line turns upward and the stretch increases faster than the force applied. The point where the line begins to curve upward is called the "elastic limit," beyond which the formula does not apply. Referring to Fig. 9, the compression or stretch produced by bending may be represented by the horizontal lines in the triangles $N N_1 S$ and $O O_1 S$. Let $N T$ represent to a certain definite scale the tensile strength of the material or the stress

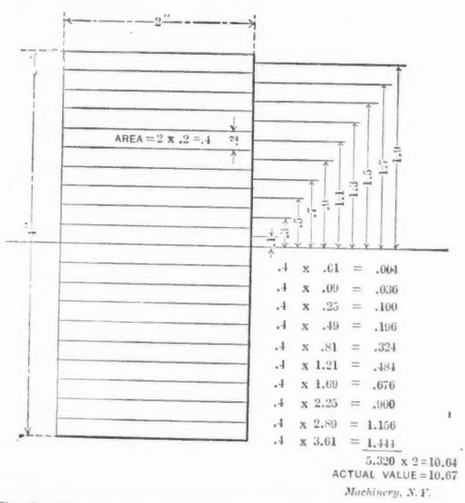
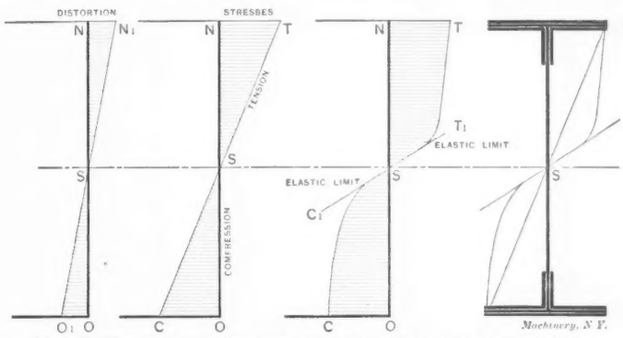


Fig. 8. The Approximate Solution of the Moment of Inertia.

in the outer fibers just as breaking occurs; then, according to the application of Hook's law made in the foregoing formula, the horizontal lines in the triangles $N T S$ and $C O S$ will represent to scale the corresponding stresses in the other fibers. But we know by actual experiment that after a certain point is reached, the stress does not increase as fast as the strain produced, so that if $N T$ in Fig. 10 represents the tensile strength of the material, the horizontal lines will represent to scale the corresponding stresses throughout the section. It is evident that the total of the moments of these forces is greater than in Fig. 9, which explains why the outer portions of a beam seem to stand a greater stress than their ultimate



Figs. 9, 10 and 11. The Apparent effect of the Elastic Limit in Raising the Ultimate Tensile Strength.

tensile stress as ordinarily determined. There is no practical method of calculating the actual breaking strength of various sections, because beyond the elastic limit the curve on the compression side is generally much different from that on the tension side if the results of the testing machine were plotted on squared paper, which means that the neutral axis no longer passes through the center of gravity. Consequently, specifications no longer specify that a beam shall be designed so as to have a certain factor of safety based on the tensile strength of the material, but state what shall be the maximum safe stress in the outer fibers; and as this is always well below the elastic limit, Hook's law holds good, and Formula 4 enables us to design beams that shall not be strained at any point beyond a known safe amount. To this extent the formula is accurate and furnishes the only means we have of securing uniform results.

In the case of a built-up section, like Fig. 11, where most of the metal is in the flanges and where the theoretical straight line of Fig. 9 and the actual curve of Fig. 10 more nearly coincide, the difference is quite small. In fact, in such a section the web would probably be ignored in computing the bending strength. But in the case of a square section, for instance, the moment required to break the beam, as determined by actual experiment, may exceed the moment as determined by equation 4, based on the tensile strength, by as much as 70 per cent. The supposed ultimate value of f, as determined by actual experiment, in bending, is generally greater than the ultimate tensile strength, and is called the "modulus of rupture."

* * *

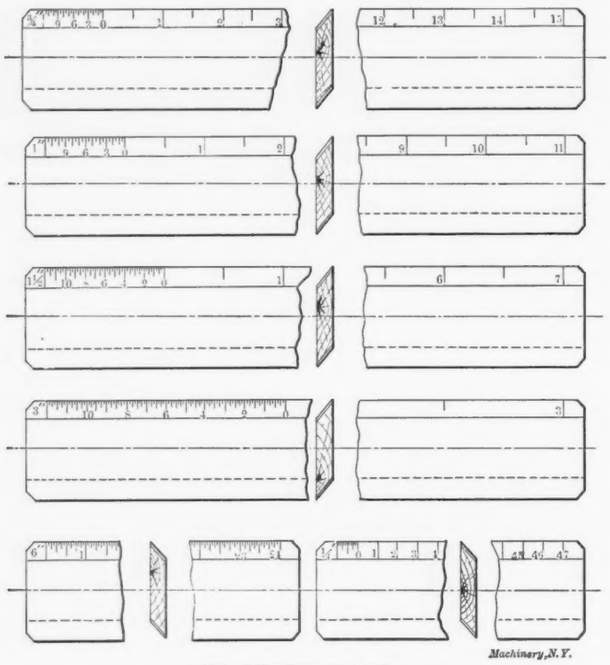
The proposed channel tunnel which we mentioned in a note in our Engineering Review in the February issue has been received by the British government with disfavor, and the bill to authorize it may be regarded as dead. The reason stated for this may seem rather ridiculous to American ears, unfamiliar with the supremacy which military matters occupy in Europe. Even supposing, it is said, that military dangers were to be amply guarded against, there would still exist throughout the country a feeling of insecurity which would lead to a constant amount of increased expenditure, both naval and military, and a general condition of unrest and alarm, which would be injurious to commercial life. On the other hand, it is said, and this view seems to be more reasonable, there has not been disclosed any such prospect of advantage to the trade or industry of the country as would really call for such a construction. Other means of communication, such as are found in great railway ferries, seem to be more easily accomplished, and ought to give as good facilities for direct communication.

SELECTING DRAFTSMEN'S TOOLS.

F. W. C.

After the earthquake and fire of April 18, 1906, I took stock of my earthly possessions and found that I had one suit of clothes (slightly damaged), my watch and a large automatic pistol. My books and instruments had been but a drop in that fiery sea which raged for three days and nights, but of all that I lost, I most regretted my notebook and the files of technical magazines I had so carefully collected and indexed. Before the ruins were cold there was work for those who wanted it, and being fortunate enough to borrow a good set of instruments for a while, I was able to go about the purchase of a new outfit in a more leisurely manner than would otherwise have been possible. A few of us had amused ourselves at times by contemplating what we termed the "pipe dream," which was supposed to be a set of instruments comprising all that is really needed by a draftsman, and by thus taking advantage of the experience of my friends as well as my own, I was able to avoid most, if not all, the mistakes a beginner usually makes in equipping himself.

The set selected was chosen with more regard to the requirements of marine and mining work than any other, but I think it will apply pretty generally to all classes of machine



Machinery, N.Y.

Set of Draftsman's Scales.

work, although there are a number of special instruments that it would pay a man to have if he handles much of a certain kind of work. If he, for instance, is on a pipe plan for a government vessel, where the lengths of all pipe must be given, an opisometer is very convenient, especially on the copper piping, or, if much boiler or structural work is handled, it is well to have a self-adjusting bow pen, commonly called a "pile driver," to reproduce a number of circles of the same diameter, as rivets or boiler tubes. I would rather not have mentioned the names of makers, but as that was a point which received very careful attention, and on which we unanimously agreed in all but a few cases, I don't think this would be complete without it. All ruling pens and pen compasses are by T. Alteneder & Sons, and are of the spring hinge type. Although this style is more expensive than the plain pen, once it is used, the user would not be without it for many times the extra cost. If plain pens were chosen, any one of the well known makes is about as good as the other, but this special one is the best of all the patent opening pens.

The three bow instruments are 3¼ inch long with center adjustment, and the range they can cover is surprising. The bow pen will draw perfect circles from less than 1/32 inch diameter to 3¾ inches diameter, and once I drew one 4 inches, but it is not well to do so if it can be avoided. There is one 3½-inch pencil compass with fixed pencil and needle points, and a 5½-inch pen compass with fixed pen, needle points, and hair spring adjustment. The pencil compass is small, because I prefer to use trams for all pencil work beyond its limits, but the pen can be used to advantage in the 5½-inch size. The hair spring adjustment on it is a great convenience, although by no means necessary. The fixed points would not pay a man who draws only occasionally, but for the man who draws all the time they are well worth the cost of the extra instrument. The two ruling pens are 5 inches and 5½ inches long, and while it is always well to have an extra pen on hand, yet I have never used the smaller.

All the foregoing instruments are the Alteneder's, but the bow pencil and dividers are made just as good by others. My 5½-inch dividers are of the well known Richter instruments and were chosen principally for the adjustable points. Some draftsmen prefer to do all laying out with the pencil or dividers, but I use a pricker in which the point is a sewing needle held by a screw. The trams I imported from Germany where they were made by C. Reifler. They consist of a tubular German silver bar in three sections, held together by long slip joints and will work to a radius of 50 inches. Both heads slide on the bar, being clamped in the desired position with thumbscrews, and the points are adjustable in either head. The delicate adjustment is of the swinging lever type, which, so far as my experience goes, is the only satisfactory one for trams. There are two divider points, pen, pencil and needle points and a knife for cutting out circles. The whole instrument is very stiff, light and of remarkably neat appearance, with a bar long enough for all ordinary work, but when longer is required it is easily spliced with one of wood. For a man who uses such a tool often, it is the best I have ever seen, but its cost would not warrant its purchase by one who would use it only occasionally.

No two men agree about triangles, but most of them prefer the transparent ones, although they are invariably too thin for the best results. At present I use a 16-inch, 30 and 60 degrees, a 10-inch, 30 and 60 degrees, and a 5-inch, 45 and 45 degrees for all ordinary work.

We all know the evils of the triangular scale, so when the old one burned up, I decided not to burden myself with another, but had a set made like that shown in the cut. It comprises 7 scales, ¼, ¾, 1, 1½, 3, 6, 12 inches = 1 foot. The full size scale is not shown in the cut. These scales are of the reverse bevel type, and both sides of each scale are graduated the same, but read from opposite ends. With this arrangement it is never necessary to more than turn the scale over to have it reading in the desired direction. The divided foot on the 1½ and 3-inch scales is marked 2-4-6, etc., instead of the usual 3-6-9, which makes it easier to find the desired point. The 6-inch scale is fully divided in 16ths and the 12-inch in 32ds. These scales were made by Alteneder and are the finest I have ever seen, with a white edge on a select piece of boxwood, while the graduation marks are very short and sharp.

For a slide rule I chose a 10-inch Keuffel & Esser adjustable, but if I used one all the time I should have taken their duplex. I have been using these instruments for several months and can see no room for improvement in quality, although I intend to add, as soon as possible, a protractor, a set of scales for indicator cards, a couple of curves suitable for propeller work, a short spline adopted to the work in which I am engaged, and an oil stone.

* * *

In a little booklet descriptive of the making of four-tine stable forks, the following occurs: "The fork then goes through the secret tempering process perfected by the company after years of experience and experiment. For obvious reasons the process is not made public." The chances are that the process is one that is practically known to every first-class temperer and hardener in the land, save that the work is adapted to the peculiar requirements of manufacture. It would seem from general observation that a secret process almost invariably plays some important (?) part in the manufacture of certain kinds of tools. People are prone to believe that a secret process must, of necessity, be something of a wonderful nature, and a manufacturer who does not have a secret process of some sort or other is not "in it."

A SHOP WITH A HISTORY.*

THE PUTNAM SHOP IN FITCHBURG.

H. P. FAIRFIELD.

A history of the beginning and development of the Putnam Machine Co. of Fitchburg, Mass., is so nearly a history of many of the older New England machine industries that it must have a genuine interest to all shop men and shop engineers.

The firm is an interesting one from the fact that since its formation, in 1835-36, it has been the Putnam Machine Co. in deed and name, and is now owned and managed by Putnams who are of the original stock.

To one interested in economic questions, the firm also has much to render it interesting regarding its methods of treating its employes. As one goes through the works, the number of elderly men at work impresses the visitor as unusual in these days of squeezing out of old men in favor of the younger members of the fraternity. At the Putnam Company the old employes *die out* instead of being forced out; nor are they degraded by having their pay reduced; neither are they made helpers or sweepers, but instead are allowed to continue as equals of the other members of the working force, and at the same line of work in which they have been serving the firm in their more valuable years.

The writer, in conversation with George Boss (a workman), learned that he had been in the company's employ as a machinist for over fifty years, or nearly the entire life of the firm, and others told a story of continuous service for like periods of time.

The originators of the firm, who have so long been identified with its name, were John and S. W. Putnam, who, previous to 1835, had been employed in some of the Lowell cotton mills as machinists. About 1835 they came to Fitchburg and established a small shop for repairing cotton machinery and any other line of medium machine work. The need of better lathes than those they could buy led them to build some for themselves, and as a demand was created, for the public. When the building of machine tools for the open market was under consideration, they removed to New Jersey, but soon returned to Fitchburg, in which city they have since remained.

John Putnam was essentially a workman, and his main interest was to produce the best work possible, and the set of gages shown in Fig. 16, made by him fifty years ago, testifies to his ability as a machinist. S. W. Putnam was undoubtedly as fine a workman as John, but possessed the additional faculties of the designer and business man, and to his and his descendants' management of affairs is due the long life and prosperity of the firm.

It is worthy of note that a grandson of the founder of the firm is at present works superintendent, a handing down from generation to generation of a machine business which smacks more of English customs than is usual in America. A degree from a prominent New England engineering college is one of the superintendent's possessions and a great aid in his life work.

Fig. 1. Main Machine Shop, with the Office showing in the Left Center.

Fig. 2. Main Foundry, Stable and Small Shops.

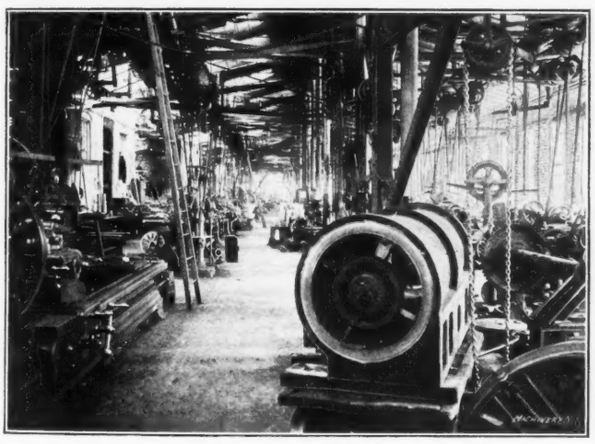


Fig. 3. Main Aisle of Machine Shop, looking from Opposite Offices.

Fig. 4. Ox Team used for Moving Materials, Castings and Machines about the Yards and to the Railroad.

The firm builds both light and heavy machinery for general machine shop equipment, but is best known from its heavy machines used so generally in locomotive shops. Its driving-wheel lathes and car-wheel borers are of the largest, and of the highest quality, as are its planers and large engine lathes.

In illustrating such a plant as this for the benefit of mechanics, an attempt has been made not only to show the place as a whole, but also to give an idea of how the work of construction is carried on in the shops. In this, only the larger work has been considered, as the small and medium machine work is much the same as everywhere, and it is in the heavier work that originality obtains.

Figs. 1 and 2 are exterior views of the works and the yards

* For additional historical notes on the Putnam Machine Company, see article under same title in the October, 1897, issue.—EDITOR.

of the company taken at one setting of the camera, but looking first to the left of the main avenue, and then to the right. The main machine shop is of single-story construction, lighted

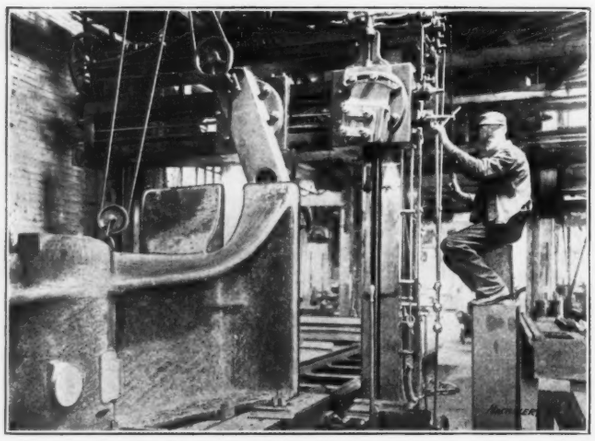


Fig. 5. Planing and Milling a Large Casting at one Setting on the Platen.

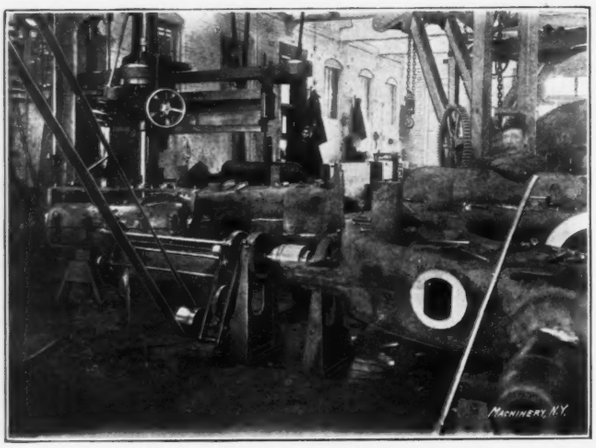


Fig. 6. Portable Boring Machine at Work. Radial Drill at Work in the Background.

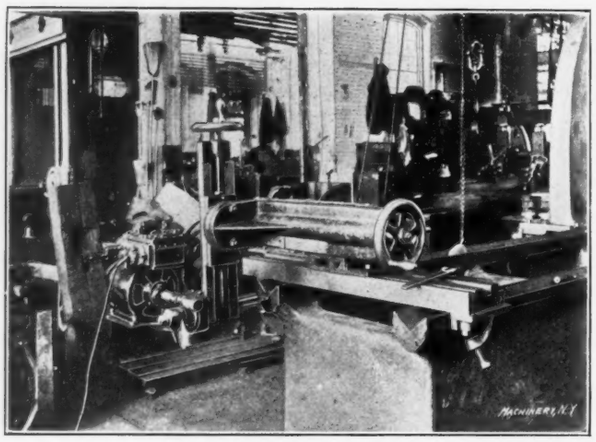


Fig. 7. Motor-driven Portable Milling Attachment for Finishing the Ends of the Ways.

mainly from roof monitors, which are placed at short intervals from each other, and the interior is in this manner lighted very uniformly. The transparent material used in the monitors transmits a yellowish light, very soft and pleasant to the eye, but a horror to the photographer on account of its lack of actinic rays.

Fig. 3 is an interior view, looking down the main aisle. To the right of this aisle the entire length of the main shop is devoted to the lighter machine work, largely lathe work. To the left is a double row of larger machines, mostly lathes. This much occupies about one-half of the width of the shop for its entire length. The remaining longitudinal half is divided into a series of small rooms by brick or other walls. Each room is open toward the main aisle, is provided with heavy machine tools, individual cranes, and is used for the heavier machine work and for erecting the heaviest machine tools. The outer or wall ends of these compartments open by means of wide doors upon the main yard avenue, making the receiving or delivery of machines and castings an easy matter.

Fig. 4 shows one of the industrial railways in general use at these works. There are several of these around the yards and shops. The engineer of the one shown, Gilbert LaPrade, says they are the best ever, and a look at their faces will convince anyone of their intelligence and honesty.

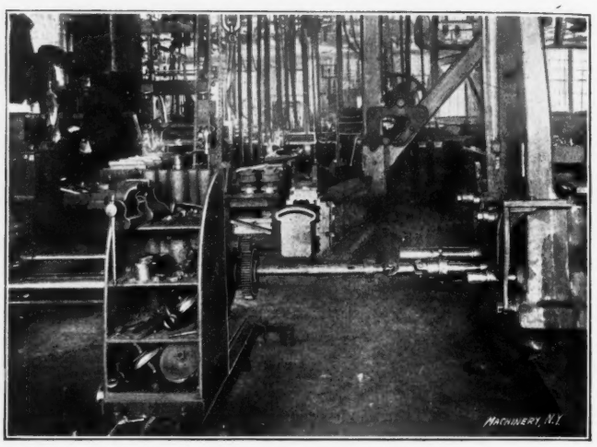


Fig. 8. Portable Boring Mill at Work Boring the Shaft Boxes on a Large Planer Bed.

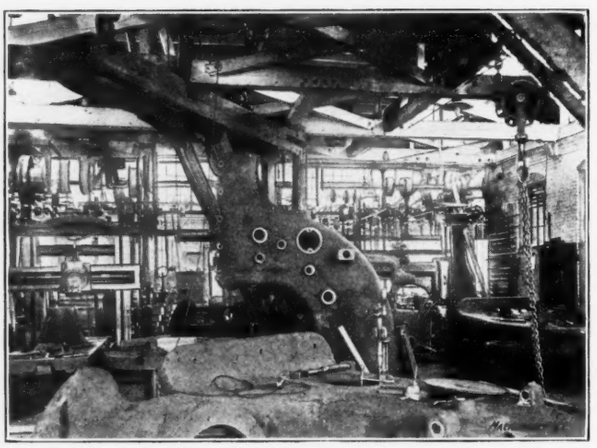


Fig. 9. Frames of Car-wheel Borers under Gib Cranes. Radial Drilling Machine in Background at Work on Casting.

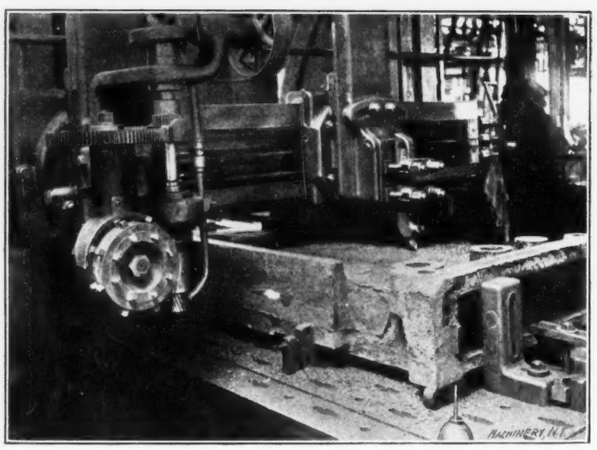


Fig. 10. Planer Fitted with Milling Attachment.

When finishing heavy machine parts it is oftentimes cheaper to finish certain surfaces by hand methods than to move them onto a machine and then line them to the cutting tool. This

leads, naturally, to devising methods of bringing the cutting tool into line with the work, or, in other words, it becomes easier to adapt the cutting tool to the surface to be machined than to take the surface to the tool. This often leads to using that most adaptable of all machines, human skill; or, as it is more often termed, hand-work. While the firm under discussion makes use of hand-work, yet a study of the illustrations, Figs. 5 to 11, will convince the reader that many things usually done by hand, or by setting on a machine, are better done by the use of portable tools, so designed as to be almost perfect in their adaptability. For example, in Figs. 6, 8, 9, 11, the drilling and boring on the heavy frames of a car-wheel borer is done by a portable boring machine which consists of

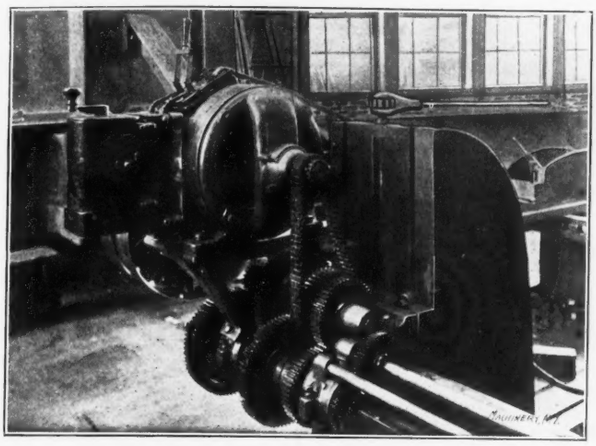


Fig. 11. Motor-driven Portable Boring Machine.

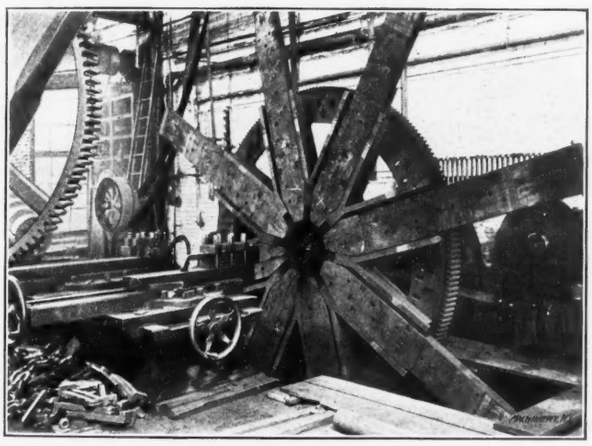


Fig. 12. Pit or Face Lathe.

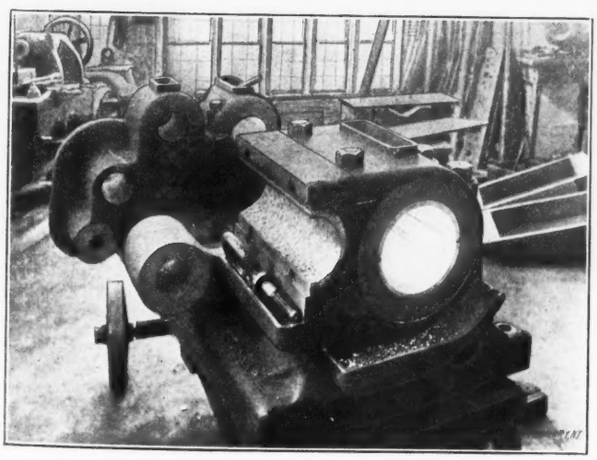


Fig. 13. Large Headstock Frame, with Babbitt-lined Bearings. Note Hammered or Peened Appearance of Left-hand Bearing.

an upright or housing which carries a rotating spindle or spindles geared to a variety of speeds. There is a vertical adjustment provided on the housing direct, and for a horizontal adjustment the housing is moved upon its base plate. As the boring bars are provided with universal joints, it is not necessary that the adjustments of the driving mechanism be special-

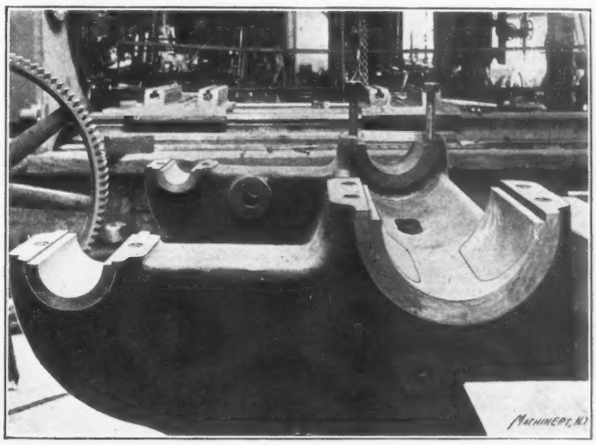


Fig. 14. Large Headstock Framed with Cast Iron Bearings. Note Oil Grooves.

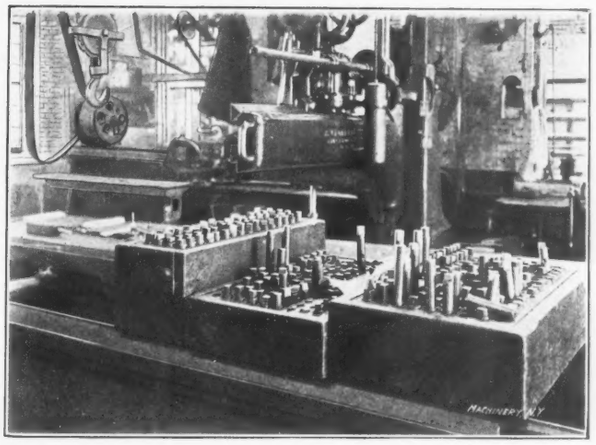


Fig. 15. Cases with Boring Bar Cutters.

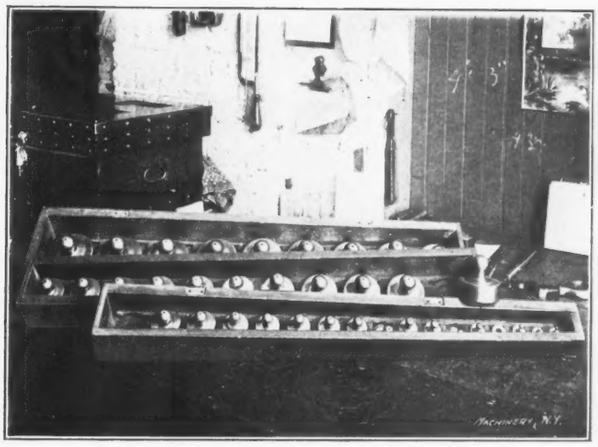


Fig. 16. Standard Reference Plug and Ring Gages.

ly accurate if the cutter bar be properly supported and guided by bushings or jigs. It will be noted that some of these portable machines are belt- and some are motor-driven.

In Figs. 5, 7, 10 are shown special milling devices contrived to do away with the necessity of hand-work or of shifting the position of the casting. Much labor is saved by the use of each of the pieces of portable machinery shown.

In Fig. 12 is shown a large and extremely old-fashioned pit or face lathe used to face off large diameters and incidentally used to do any job that fails to fit elsewhere. In the heavy machines built by this firm two kinds of bearings are used, as shown in Figs. 13 and 14. Fig. 13 illustrates a bearing lined with babbitt metal. It will be noted that one of the

bearings in this cut was unfinished when photographed and shows the hammer marks of peening the lining into contact.

In Fig. 14 is shown a plain cast iron bearing, and the oil grooves to distribute the lubricant. The spindle fitted to this bearing has a low rotative speed, but the pressure per inch of projected area is considerable.

Fig. 15 shows the method of storing the cutters used in the boring bars. It will be plain from the various views that there is a large amount of boring bar work, and that many cutters are needed. These cutters are all marked for the size of hole they will bore, and stored in the cases as shown. Mention has already been made of a set of gages made by John Putnam as a set of test standards. Fig. 16 shows these in their cases. As shown, the plug is slipped into the ring and each individual piece is a plug and ring gage. These were made in the early days of the firm and have been the standard to which they have since worked. Two or more of the plugs of an aggregate size of some ring can be placed in the ring, and the fit appears to be perfect to-day, and I understand that this was one of the means used to test their accuracy while they were being made.

* * *

THE DEMANDS ON A GENERAL FOREMAN IN GERMANY.

Werkmeister Zeitung, No. 6, 1907, gives an example of what certain employers in Germany demand of a general foreman. A gentleman looking for employment received from the firm in question the following specifications regarding his duties, and the following questions regarding his willingness to comply with the demands. In the first place, he was required to give his age, religion, conditions of military service, health, whether married or single, whether he had children, and how many, if he was employed at present or not, and if not, the reasons why; whether he would be willing to punctually follow the schedule of the shop from 6 A. M. to 7 P. M. in the summer and from 7 A. M. to 7 P. M. in the winter, excepting two hours for meals; to work overtime when necessary without extra compensation; to carry out on Sundays, before church service, such repair work as could not be done when the shop was running; to take care of the engines when the engineer was not present; to himself work at the bench when necessary; to see that all necessary requirements in regard to safety appliances were in good order in the shop, and to pay out of his own pocket any damages to employes hurt during work on account of lack of safety devices (the previous general foreman had done this). After this came questions regarding his experience and efficiency; whether he was able to personally, without help, take care of steam engines and boilers; to carry out personally in the repair shop all necessary repairs on machine tools, transmissions, steam engine and boiler, and plumbing work; whether he could independently make up cost estimates and lay out plans for smaller factory establishments; whether he was efficient in the caring for the electrical power and light station; if he was completely acquainted with dynamos, and could take care of accumulators; how long he had independently superintended the care of such apparatus; if he could make all necessary electrical repairs without help, and carry out extensions in electrical wiring; and finally if he was fully acquainted with the establishment of telephone and signal systems and with electrical elements.

It is said that the gentleman looking for the position made up his mind not to aspire to the job in question. It is, however, to be regretted that the German firm seeking for so efficient a man has not been able to communicate with the "General Engineer and Electrician" of English origin whose advertisement for a remunerative job we could not refrain from presenting to our readers in the March issue of MACHINERY, Engineering Edition, page 384. This little note and that go very nicely together, and, in view of it all, how futile seems the expression that this is an age of specialization!

* * *

Don't forget that some machinists can do more and better work with a $2.75 kit of tools than some others can do with $100 worth of tools in morocco cases.

THE LINK MOTION OF THE HANNA RIVETER.

There are two essentials in rivet driving with portable tools, or with any other kind of tools for that matter. These essentials are, first, that the work be done expeditiously, and, second, that it be done effectively. The first requirement is favorable to the pneumatic riveter in some of its forms, while the hydraulic type has decided advantages over the pneumatic machines, as usually constructed, when the second consideration is taken into account. Among the general types of portable riveters may be mentioned the "simple hydraulic," the "hydro-pneumatic," the "pneumatic lever" and the "pneumatic toggle joint" varieties. In the plain hydraulic type the die is driven forward by the direct pressure of a ram or piston, under a compression of from 1,500 to 10,000 pounds per square inch. The full maximum power for riveting is obtainable throughout the length of the stroke, and the pressure applied to the rivet is known and unvariable. For disadvantages, the trouble and expense of maintaining hydraulic packings might be mentioned, as well as the difficulty of using flexible joints in piping for fluids under high pressure; the power supplied

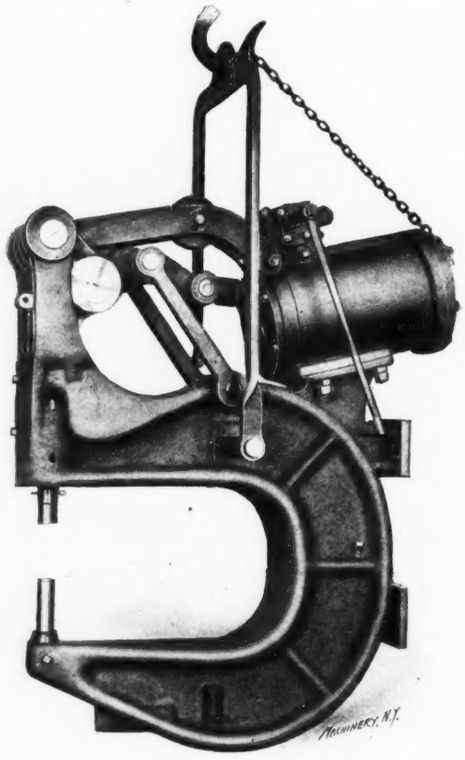


Fig. 1. The Hanna Pneumatic Riveter.

is also used in a wasteful manner. The hydro-pneumatic scheme employs the same direct connected piston, operated at will, however, either directly by air at low pressure or indirectly by high fluid pressure obtained from a self-contained intensifier. This is as effective as the plain hydraulic machine, but has the same packing difficulty, with the added aggravation that a slight leakage of air into the high pressure chambers renders the machine inoperative. The pneumatic lever machine is operated by a simple lever connected to the ram at one end and to a piston rod at the other, with a pivot between them. This device has the advantages of the hydraulic machine without its disadvantages, and works very well for small rivets. When, however, it is applied to ordinary structural, bridge and boiler work which requires rivet pressures ranging from 50 tons to a possible maximum of 100 tons, the diameter of piston required to furnish this with the usual working pressure of 100 pounds per square inch, is so bulky as to make the machine heavy and clumsy beyond the limits of a portable machine.

The toggle joint type is the one usually adopted. In this machine the riveting die is attached to one member of a toggle mechanism, of which the other member is joined to

the main frame of the machine, the piston rod from the pneumatic piston being attached to the center joint of the toggle and working at right angles to the movement of the die. This arrangement gives the desirable conditions of rapidity of action during the first part of the stroke and high pressure at the end. It is not possible, however, for the operator to know just what pressure he is exerting on the rivet. This depends entirely on the length of the rivet as compared with the distance between the dies when the mechanism is closed. Suppose, for instance, that a rivet has just been driven under proper conditions. With the die adjustment remaining as it was a second rivet is driven, the air pressure as in the first case forcing the piston to the extreme limit of its travel. The operator has now no assurance that the pressure obtained is the same as in the first case—the rivet may be a trifle shorter. If he is trying to do careful work he will return the riveter to its open position, close the dies together a trifle by the screw adjustment provided, and give a second blow on the same rivet, repeating this until the piston is just barely able to complete its stroke against the resistance offered to it. This assures him that the maximum pressure obtainable has been reached.

The procedure just described is necessitated by the fact that the toggle mechanism does not give the maximum pressure until the extreme end of the stroke has been reached, so that a full stroke has to be taken every time, and the dies have to be adjusted to accurate length for each operation in order to be assured of obtaining the desired results. If it were possible to so connect the piston and the ram that the maximum pressure could be obtained for a considerable distance, say one-half or one-quarter inch, the stopping of the mechanism anywhere within the limits of that distance would assure the operator that proper pressure had been applied, and that the riveting was well done.

This desirable result is attained in the link motion applied to the riveter shown in Fig. 1; the line cut, Fig. 2, and the skeleton diagram in Fig. 3 will serve more clearly to explain the action obtained. The same reference letters apply to the

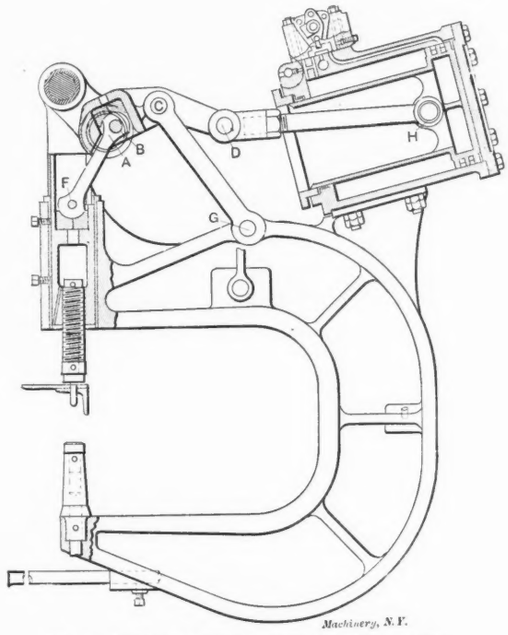


Fig. 2. Details of Construction of the Hanna Riveter.

same parts in Figs. 2 and 3. At *H* is the pivot between the piston rod and the trunk piston used in this machine. It is pivoted at *D* to the main lever, which is partially restrained in its movement by the guide links on each side, pivoted to it at *C* and to the frame at *G*. Projecting journals on each side of the main lever have their bearings at *A* in the upper toggle links, which are hinged to the frame at *E*. The lower toggle link seats in composition sockets with center lines at *B* in the main lever, and at *F* in the plunger.

The first position in Fig. 3 is that shown in the line cut in Fig. 2. The second position of Fig. 3 shows the piston with its stroke half completed. Of the 4-inch movement provided for the die, 3½ inches has been accomplished at this position; it is almost entirely effected by the toggle action resulting from the straightening out of links *A E* and *B F*. This movement was at first rapid, slowing up toward the end, when the maximum pressure available is reached. In moving from the second position to its third and final position, as shown in Fig. 3, the toggle movement has practically ceased, and the action is now that of a lever with power applied at *D*, with fulcrum at *A*, and with the working pressure taken from pivot *B*. Thus, the second half of the piston travel is entirely occupied

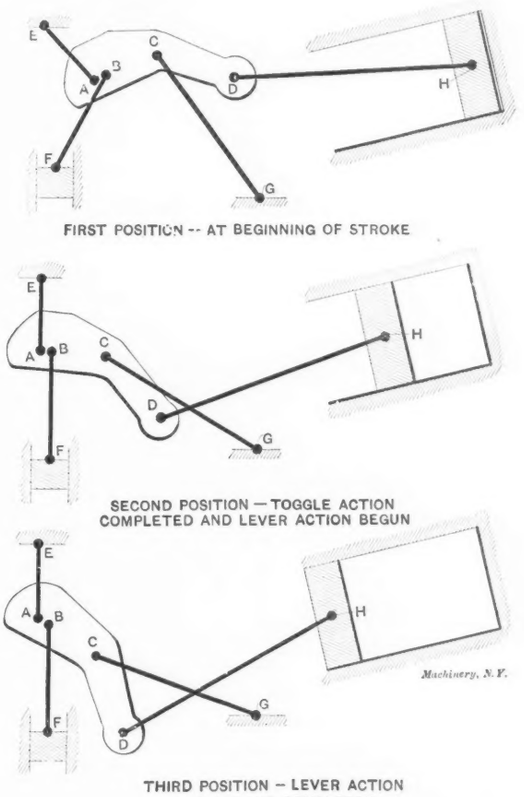


Fig. 3. Skeleton Diagram showing the Linkage Mechanism in three Positions.

in giving, by this means, the last half inch of steady maximum pressure of a known intensity, regulated by the size of the cylinder and the air pressure used. We have had the privilege of examining an aluminum model of this motion which shows its action very nicely. The piston in this model may be moved to successive graduations representing even inches of piston travel—twelve in all. Graduations on that part of the model corresponding to the plunger guide show the position of the plunger for each of these evenly graduated positions; the scale is reproduced in Fig. 4. It will be seen that

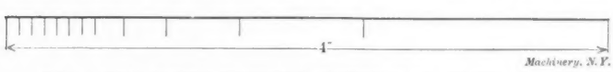


Fig. 4. Scale showing Successive Positions of Die for Even Divisions of Piston Travel.

the first 5 inches of the piston travel gives a constantly decreasing velocity to the die, while from the fifth to the twelfth graduations it travels with a nearly uniform velocity—a condition which, from well known laws, augurs a uniform pressure.

The advantages derived from this condition are easily understood from what was said in the opening paragraphs. On account of the considerable distance through which maximum pressure is exerted, careful adjustment of the die screw is not needed, and there is no necessity for striking a rivet more than once. Since the first half of the stroke of this riveting machine is identical with the full stroke of the toggle joint machine, the same care used in the operation will give the same results with considerably less air than is used by the latter type, a position which is further strengthened by the

fact that only one stroke is required even with the most careless working, where from 2 to 4 may be needed with the ordinary mechanism. Greater speed, also, naturally follows from the fact that but a single stroke is ever required, and that it is not necessary to make constant readjustments. As regards the matter of readjustment, it is possible, for instance, to drive a rivet through two ½-inch plates and then pass immediately to the driving of a rivet through three ½-inch plates without altering the position of the die; the pressure given to each of the two rivets will be the same. Finally this pressure is, as has been stated, predetermined in intensity.

The model previously mentioned is a fascinating piece of mechanism to operate. As the piston is moved down by the hand, the die is started rapidly forward, quickly arresting its motion, however, as the piston reaches the middle of the stroke; from there on its movement is slow and steady. This combination of toggle joint and lever actions, operating in succession without over-lapping each other's movement to any extent, shows ingenuity of a high order on the part of the originator of the scheme. The Hanna Engineering Works, of Chicago, build riveters using this patented mechanism.

* * *

MORE LIBERAL POLICY REGARDING THE AGE LIMIT OF EMPLOYES.

The age limit for employes hired into the service of the Pennsylvania Railroad Co. has been changed from 35 to 45 years. It was announced in the March issue of MACHINERY that President James McCrea would recommend that the change be made from 35 to 40 years, but at the annual meeting of the directors in March the change was made to 45 years instead. This change will be generally welcomed by industrial workers, for the policy adopted by this and several other large corporations a few years ago worked great hardship to many men, and was severely criticised. The placing of an age limit, however, was not a declaration that a man who had reached 35 years was unfit for future service, but it was simply the logical outcome of adopting a pension system under which all Pennsylvania employes are compulsorily retired when they reach the age of 70; they may voluntarily retire between 65 and 70. The pension of an individual is based on his average wage for the ten years prior to retirement and his total years of service. Hence it follows that there must be a certain age beyond which men cannot be taken into the service in order that all may enjoy the benefit of the pension system. The change to 45 years will probably make some change necessary in the pension regulation. The difficulty in getting skilled workmen at the present time was undoubtedly one strong reason for making the change. Many of our best mechanics did not acquire their greatest ability until they were well along toward middle life, and in order to avail themselves of the services of such men, the large corporations will generally be obliged to extend their present age limits. It may be with some corporations that there will be a class hired into service outside the pension benefit scheme, and this, in effect, has already been in vogue with the Pennsylvania Co. The master mechanics were given the privilege of hiring emergency men over 35 years of age for a period not greater than six months. At the expiration of six months they were discharged, and if still required, were immediately hired over again. This subterfuge permitted many of the repair shops to keep in service men beyond the recognized limit and still not make them eligible to the pension benefit.

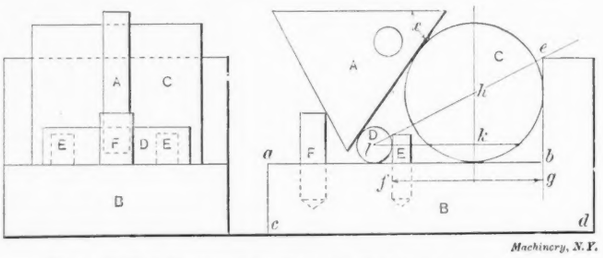
* * *

It has been interesting to note the behavior of the London motor omnibuses during the recent frost and snow, which has been the most serious test of this nature that has occurred in ten years. As might be expected on ice covered roads, horses could barely stand; motor omnibuses, however, were able to proceed on their way without much trouble. During the thaws alternating with the frost, of course, both horse and mechanical traction suffered, as the thawing snow on the hard under pavement produced a very slippery, skiddy surface. On the whole, the motor omnibuses came out exceedingly well during this cold period, and, it is stated, much better than any other class of public vehicle.—*Horseless Age.*

THREAD TOOLS FOR THREADS WITH ROUNDED TOP AND BOTTOM.

E. A. JOHNSON.

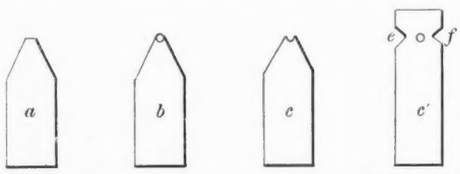
While the development of a correct United States or V-thread tool is a thing requiring a great deal of skill and patience, it is easy compared to the task of producing a tool for the round top and bottom thread, of which the Whitworth and British Association standards are the leading examples. In testing for accuracy, threads of this type are not only measured by gages and micrometers, but the curves must match the angle so evenly that when the male gage is tried in the female from either end, no difference can be detected. The difficulty attending this will be the better appreciated when it is known that some of the leading tap and die manufacturers of this country and Europe have failed in producing threads that would pass the British government's inspection.



Machinery, N.Y.

Fig 1. Method Employed for Obtaining 55 Degree Angular Gage.

It may be laid down as a cardinal principle that the best results are obtained by developing the form first with a flat top and bottom as in the U. S. thread, rounding the corners afterward. The first step of all is to produce a correct angle gage; assuming that we are to work out the Whitworth thread, this would be a gage measuring 55 degrees. Make and harden a steel triangle *A*, Fig. 1, with the angle x as near 55 degrees as is possible by using a bevel protractor; the other two angles are to be equal. Then make an angle iron *B*, making sure that $a\,b$ and $c\,d$ are parallel, and that $b\,e$ is square with $a\,b$. Assuming that *C* and *D* are accurate 2-inch and ½-inch plugs, we put in the pins *E E* in such a position that a line drawn through the centers of *C* and *D*, at right angles to their axes, will make an angle of 27½ degrees with $a\,b$.



Machinery, N.Y.

Fig. 2. Tools used for making Whitworth Thread Tools.

This can be done by figuring the distance $f\,g$ as follows: In the triangle $l\,h\,k$, $h\,k = 1 - 0.25 = 0.75$ inch.

$$l\,k = \frac{0.75}{\tan 27\tfrac{1}{2}\text{ deg.}} = \frac{0.75}{0.5206} = 1.4406 \text{ inch.}$$

1.4406 + ½ diameter of *C* − ½ diameter of *D* =

$$1.4406 + 1 - 0.25 = 2.1906 \text{ inch} = f\,g.$$

Set the pin *F* near enough to *D* to keep the corner of the triangle from striking the angle iron *B*. Mount the triangle *A* as shown, and set up the fixture on a surface grinder table using a toe strap in the small hole in *A* to hold it in position, and grind first one edge, then the other. This gives us the male angle gage. A female gage can be made to this by the method described in the January issue for U. S. thread gages.

The tools to be used in making the thread tool (see Fig. 2) include: an angular tool with a flat point, the width of the point to be such that it reaches to the center of the round in the bottom of the thread, the angle of the tool matching the gage previously made; a female radius tool for forming the point; and a male radius tool for the side radii. For convenience in measuring and getting the exact form required, these tools should be made with the top square with the face at the cutting edge, *i.e.*, without clearance. The sides and back of all should be ground as well as the top. The tool *a*

can be ground by means of an angular block made in the same manner as the male angle gage and should be finished by lapping. The tool *b* can be made in two pieces, one a hardened, ground, and lapped wire, and the other a soft piece made up in such shape that the wire can be soldered or otherwise firmly fastened to it in the correct position. The tool *c* should be made up first as at *c'* and hardened. Then lap the hole carefully to size and grind the outside. After measuring the distance from the hole to the back of the tool, the front can be ground off to *e f* and the bevels ground until the depth of the round part is right.

We now require a shaper with an apron made up to hold the tool-holder at an angle of 15 degrees, as shown in Fig. 3. The apron should fit the clapper-box perfectly. If it does not, it is better to fasten it solid, and let the tools drag back through the cut, sharpening the tools over again before finishing. Otherwise, one runs the risk of side shake. With this angular apron we can use the tools made without clearance to produce a tool with correct clearance for the lathe. Two thread tool blanks, one, *a*, of tool steel and one, *b*, of machinery steel, should be set up on the table adapter as shown in the cut with spacing parallels between to avoid interfering with one while planing the other. The blanks should be planed off to exactly the same height, and all measurements for height should be figured from the line *c d*, allowance being made for the difference caused by the 15-degree clearance. Then, after measuring the tools previously made carefully, to

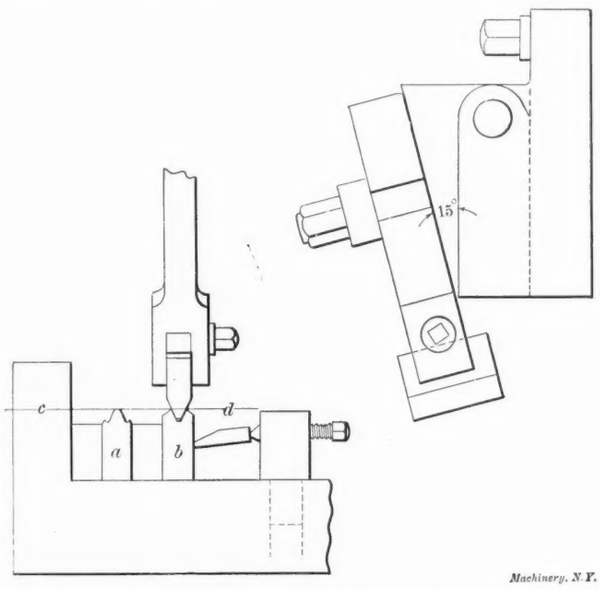


Fig. 3. Method of Planing Whitworth Thread Tools.

determine where the exact center is, we can start forming the blanks, setting the tools sidewise successively by positive measurement from the rib of the adapter. The angular tool comes first and with it we plane down the sides of the tool *a* and the center of *b* so that the point of the tool just reaches the center of the radius. Then using the female radius tool we round the point of *a* and the two points of *b*, coming down until the circle of the tool is just tangent to the top of the blanks. The male tool will round out the two lower corners of *a* and the center of *b*, being fed down to exact depth.

We now have the thread tool *a*, which can be hardened and the machinery steel blank used as a lap to correct errors in it, reversing the lap occasionally, and using oilstone powder or other fine abrasive as the cutting medium. Great care must be used in putting on the abrasive, as in all lapping operations of this kind points and corners are apt to lap faster than wide surfaces. This operation does not really correct the tool, but equalizes the errors due to imperfect matching of the different cuts, and it can be done so effectively that whatever errors of that kind are left cannot be detected.

To test the tool, turn up a blank plug with a teat equal to the diameter at the bottom of the thread. When this is threaded the point of the tool should touch the teat just as the outer corners touch the top of the thread. In the angle, the thread should measure by wires, as explained in the January issue, according to the formula:

$$\text{Diameter of screw} = \frac{1.6008}{\text{No. threads per in.}} + (3.1659 \times \text{diameter of wire used}) = \text{micrometer reading.}$$

For the final test of the fit of the curves with the angle, a tap must be threaded with the tool, and a female gage tapped with the tap. The plug made before must screw into this with an equal amount of friction from either end and show a full contact on the thread. If this last test is not successful it shows that the lapping is not good enough and must be done over. If the plug does not measure right it is necessary to go back to the planing and plane up another tool, making such allowances as one judges will correct the error. It is sometimes necessary to do this several times before a perfect tool is produced. In the use of the tool in the lathe, great care is necessary to see that it is set at the center of the spindle, and so that the two side curves will scrape the top of the thread at the same time. With the exception of making the angle gage and tool grinding block, this whole procedure has to be carried out for every pitch required.

* * *

METHOD OF REPAIRING CRANKSHAFT.

A correspondent to the *Scientific American* describes a method employed by him in repairing steel crankshafts of a compound high-pressure engine, 250 horsepower, used on a hydraulic dredge on the Mississippi River. The steel shaft 6 inches in diameter, broke about 10 inches from one of the cranks. The repair was made by facing the broken ends off square in a lathe and boring a hole in each piece 4 inches in diameter and 5 inches deep, and threading it 4 threads per inch. A steel plug or dowel 4 inches diameter and 10 inches long was turned and threaded the same pitch. The broken parts were screwed together with the dowel, the dowel having first been dipped in salt water so as to rust it fast. The work was done as an emergency repair, but it proved to be permanent. The dowel was threaded in a direction, of course, that caused the ends of the shaft to screw together under the impulse of the drive, the engine evidently not being of the reversing type. The shortening of the shaft, due to facing off the broken ends, did no harm. It was suggested by the correspondent that the friction between the outer ends of the shaft took up much of the torsional strain so that a comparatively small part was actually carried by the 4-inch dowel. Inasmuch as this repair was so effective, it was also suggested that the accepted method of connecting shafting in shops might be displaced by screwed ends. The shaft would be cheaper to manufacture and much neater in general appearance, having no flanged connections whatever. But even if such a connection were found reliable it would have the very serious disadvantage in case of a broken section, that each part of the lineshaft would have to be shifted endways several inches in order to replace the broken part, and this is enough to kill the whole scheme even if the actual connection were found to work satisfactorily—which we doubt could be the case.

* * *

The automobile industry has created a number of new occupations, previously unknown, but none, it might be said, more unique than that of the tester. His duty, says the *Horseless Age*, is to take the assembled engine with the very roughest equipment in the way of body and wheels, and thoroughly try it on the streets and roads in the vicinity of the factory. For ten hours per day, except when changing cars, the tester is at his post. To some people this would seem to be more or less ideal, and it undoubtedly is, in pleasant weather and in the absence of breakdowns, but the choice of weather does not lie with the tester, and the automobile industry does, as yet, not know of an engine designed that does not frequently break down. The tester makes in the course of a season an enormous mileage, and he learns every bit of the roads around the factory and all the neighboring towns and villages.

TWO GERMAN BEVEL GEAR SHAPING ATTACHMENTS.

There are evidences of unusual activity in Europe in the design and construction of gear-cutting machinery in all its forms. As further evidence of this activity, beyond what we have already presented, we illustrate herewith two devices of a kind not built, so far as we know, by any machine tool maker in America. These two devices are designed for planing bevel gears, and use templets or cams in giving the proper shape to the tooth. They are intended to be clamped to the shaper table.

The first attachment, shown in the halftone Fig. 1 and in the line cut Fig. 2, is built by the Act.-Ges. für Schmirgel- u. Maschinen-Fabrikation, Bockenheim-Frankfurt am Main. The attachment is fastened to the shaper table as shown, with bar *G* carefully aligned with the ram by an indicator or otherwise. The bevel gear to be planed is carried by the arbor shown. This arbor is rotated by the worm and gear in conjunction with the index plate. The worm and index plate are mounted in a quill in the head which allows them to swing about the axis of the arbor through a limited movement, independently of the indexing. The head *S* is bolted to a quadrant pivoted at *A*, about which as a horizontal axis, it may swing in a vertical plane. This swinging is effected by

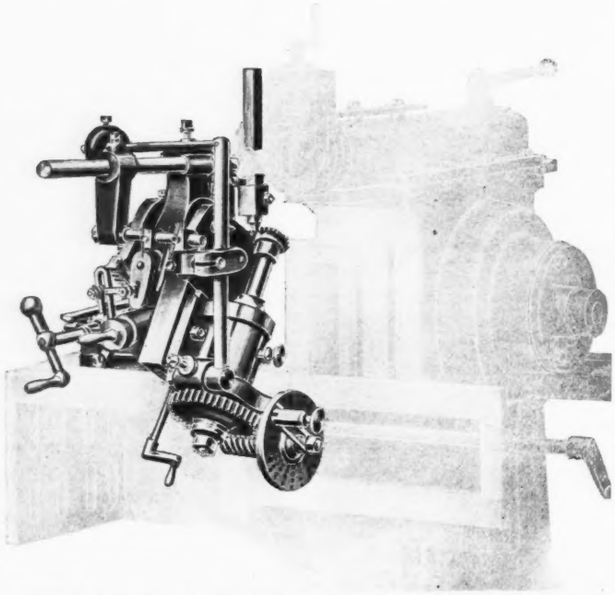


Fig. 1. Attachment for Finishing Bevel Gear Teeth in the Shaper by the Templet Process.

a quadrant having worm-wheel teeth cut upon it, meshing with a worm operated by the crank handle shown at the extreme left of Fig. 1. This crank handle may receive its motion from a ratchet feed arrangement actuated by the movement of the shaper ram. The bracket with its quill, which was mentioned as being journaled in the work spindle head and carrying the index arm and plate, has adjustably mounted to its outer end a post *B*, to which a holder is attached for carrying the templet it is desired to use. An outer arm *C*, suspended from bar *G*, carries a roll which is adapted to engage with the edges of the templet *D* and thus control the action of the blank with relation to the cutting tool.

In setting the machine for a roughing cut, a tool should be used a few thousandths smaller than the width of the tooth space of the bevel gear at the bottom. A pin at *S* is pushed in to lock the arbor-carrying sleeve with the head. The work is adjusted on the arbor until the elements of the gear blank converge at point *A*, the feed is thrown in, and the cut is started. The action is simply that of swinging the blank upward about point *A* until the proper depth is reached. In finishing, however, the templet *D* is used. The weight shown in Fig. 1 is swung either to right or left, depending on which side of the templet is being used. The copying roller engaging with this templet throws the post *B* over to one side more and more as the sector and the work are raised by the automatic feed, and the shape of the templet (allowance having been made for the shape of the roller and the tooth point) is reproduced on the tooth. The locking pin at *S* has, of course, been withdrawn during the finishing operations.

The machine is particularly flexible, owing to the manner in which the templet is supported. The templet may be moved toward or away from the center *A*, may be tipped to the right or left or may be raised or lowered. The article by "G. L. H."

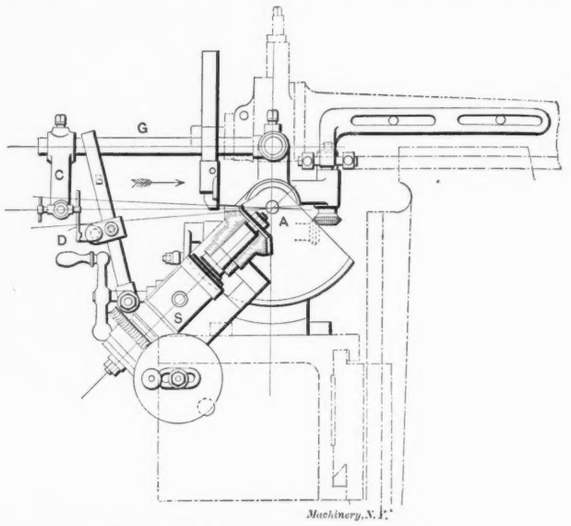


Fig. 2. Details of the Device shown in Fig. 1.

in the December, 1906, issue of MACHINERY entitled "Adjustable Former for Bevel Gear Planing," explains the way in which one templet may be used for various sizes of gears, if provision is made for locating the templet at any desired distance from the cone point.

The second machine, of which a halftone is shown in Fig. 3 and line cuts in Figs. 4, 5 and 6, is the invention of Prof. Moritz Kroll. The machine illustrated was built for his use in the Government Trade School in Pilsen.

The device consists of a frame *B* swung on pivots *Z Z* journaled in uprights $F_1 F_2$. The work spindle *A*, journaled in head *B*, carries the arbor to which the blank *R* is attached.

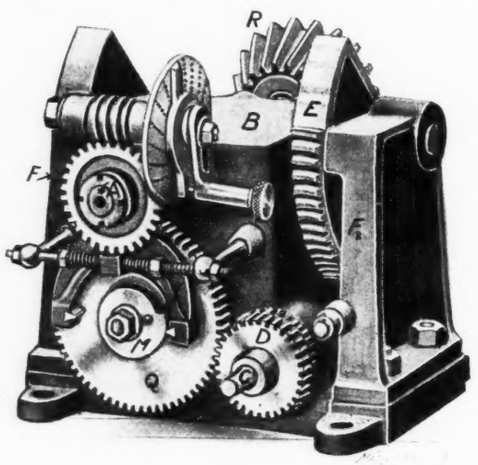
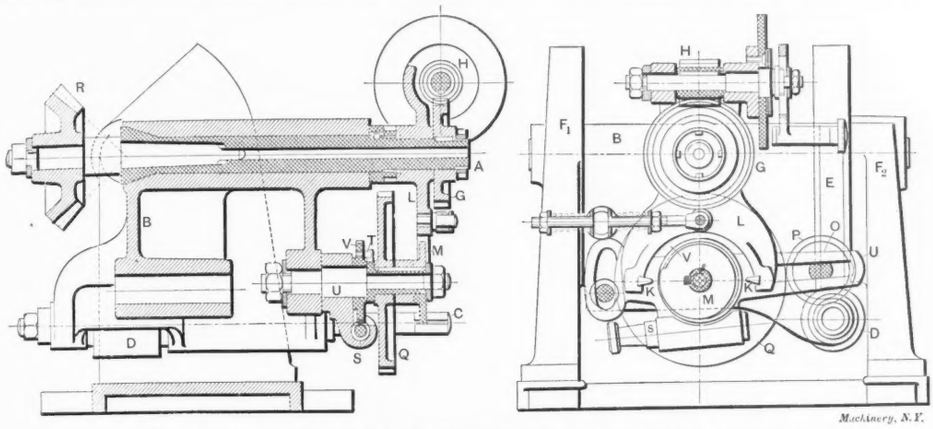


Fig. 3. Prof. Kroll's Bevel Gear Shaping Attachment.

The blank is so located on the arbor that the elements of its pitch cone surface converge on the axis of pivots *Z Z*. Spindle *A* is indexed by the worm-wheel *G* and worm *H* with the index plate shown. Worm *H* and its index plate are mounted on a loose bracket *L*, which has two outward extensions carrying hardened bearing pieces *K K*, which receive movement from the cam *M*. *L* is so connected with the double spring shown that either of the two blocks *K K* may be pressed on the cam *M*, depending on which side of the tooth it is desired to take a cut. Cam *M* is keyed to a sleeve which revolves

with gear Q. This gear in turn, through change gears, is connected with shaft C and worm D. Worm D engages a toothed sector E, which is fast to standard F_2.

It will be seen from this description that if a crank be applied to the squared end of shaft C and the proper direction of rotation be maintained, worm D and wheel E will give the blank an upward swinging movement toward the tool of the shaper on whose table the attachment is mounted. At the same time the connecting gearing D, O, P, Q will revolve cam M, which, acting through bearing block K and arm L,



Figs. 4 and 5. Section and End Elevation of Kroll's Bevel Gear Shaping Attachment.

will give a slight rotary movement to the spindle, and the combination of the two movements will result in a curved tooth contour. If cam M has been skillfully made for any given tooth shape, we can depend on an accurate reproduction of the desired form for each tooth of the gear.

In the *Zeitschrift für Werkzeugmaschinen und Werkzeuge* for January 15, 1907 (in which the description appears from which our information is taken), Prof. Kroll has given a complicated mathematical proof of the proposition that it is possible (for a given pressure angle) by the use of change gears D, O, P, Q, to use one cam or former M for making involute bevel gears of any desired pitch, number of teeth, and cone angle within the dimensional capacity of the ma-

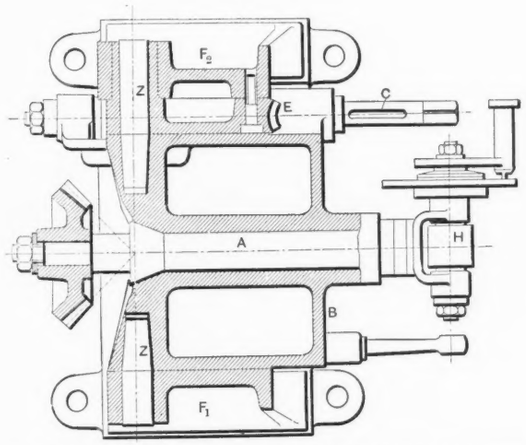


Fig. 6. Horizontal Section and Plan of Bevel Gear Shaping Attachment.

chine. It will perhaps be possible, however, by referring to Figs. 7 and 8, to understand how this is true without following the mathematical proof. Gears B and C in Fig. 7 have identically the same number of teeth and the same face angle; the diameters and the pitch of the teeth are different. Drawn in the position shown, however, it will be seen that the larger gear is but a continuation of the smaller one, so it is evident that both of them might be made at the same setting of the machine.

As is well known, and as was intimated in the article in the December, 1906, MACHINERY (before alluded to), the shape of a bevel gear tooth is ordinarily taken as equivalent to that of a spur gear having the same back cone radius. This radius, designated by Q in Fig. 7, is the same for both gears A and B of that cut. The angles of these two gears, however, and the number of teeth, are different. The pitch at the outer end of the tooth is also different, that of B being the greater. In the elevation between A and B, 2—0—4 is the tooth outline for gear B, while 1—0—3 is that of gear A. The latter is identical with the former so far as it goes, but owing to the fact that it belongs to a smaller tooth, it takes only a portion of the full curve. If a cam S, Fig. 8, were made to be used in the attachment just described of such shape as to give to gear B a tooth outline 2—0—4, using that portion of the periphery from 2 through 0 to 4, it is evident that, by using a correspondingly shorter length of the periphery (namely, 1—0—3), we ought to be able to produce the smaller pitch tooth of gear A. The angular movement of the blank about the axis of the work spindle required for this, however, will be greater in proportion than in the case of gear B, since the ratio of Q to the actual radius R_2 is greater. The necessary change is effected by the change gears.

We have now found it possible to make with the same templet gears A and C, although these two gears differ from each other in every possible point, both as to face angle, number of teeth, pitch, diameter, etc. It will also be evident that any other gear within the range of the machine may be cut, providing the proper change gears are used. A little thought will show that this principle also is based, though somewhat obscurely, on the idea described by "G. L. H." The advantage

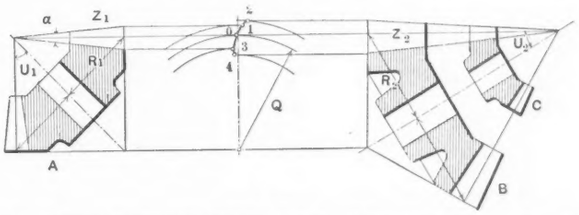


Fig. 7. Diagram showing the Shaping of Different Gears with the same Templet.

of this use of a single templet with change gears provided for varying face angles, is that a correct cam or former may be made once for all. When it is desired to cut a gear of a pitch and angle which has never been cut before, the purchaser of that gear need not fear the chances for error which would be present if the accuracy of the tooth form depended on the conscientiousness of the draftsman who made out the original curve, the ability of the workman who made the templet from the drawing, and the carefulness of the operator in adjusting the templet in the machine.

It is hoped that this description of these two German devices will stimulate some American manufacturer to do something along the same line, although most of them are probably busy enough already. The device might operate, like those described above, on the templet plan, or it might be a machine of the generating type. There ought to be a field for shaper attachments of this kind in medium-sized machine shops and on automobile repairs, for instance. In fact, we had an inquiry from a gentleman engaged in the latter business something over a year ago for some device of this kind. He asserted that he was unable to cut bevel gears on the milling machine so they would run quietly and smoothly enough for automobile work, and he hesitated some at purchasing the comparatively costly machinery necessary to plane them by the former or generating processes.

Fig. 8. Templet used in Cutting the Gears in Fig. 7.

CUTTING TAPER THREADED TAPS WITH CHASERS.

ERIK OBERG.

The cutting of taper threaded taps, such as pipe taps, with chasers is more or less common in shops where taper taps are manufactured, but the operation usually causes some difficulties. In itself the problem is very simple and the difficulty has probably originated in an insufficient analysis of the subject. We will consider the conditions of cutting a taper thread with a chaser, and particularly consider the case of

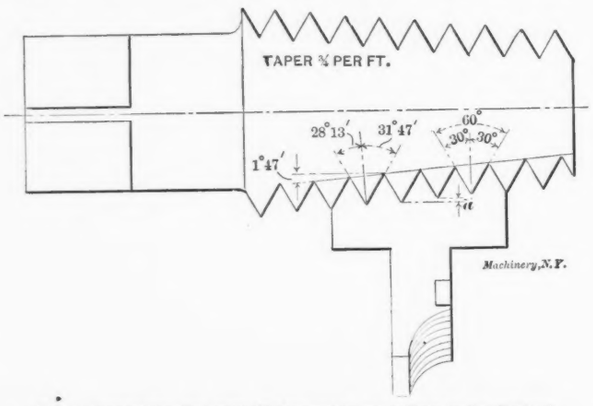
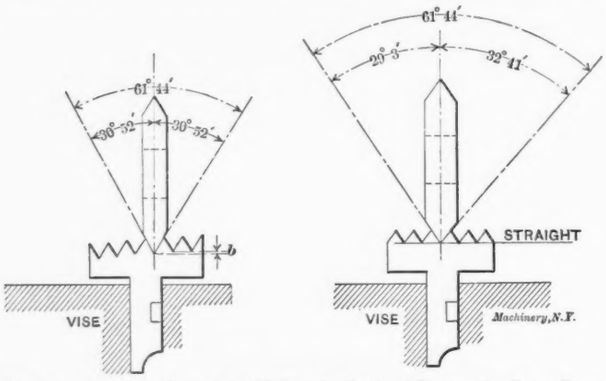


Fig. 1. Taper Tap Cut with Chaser made according to the Method shown in Fig. 2.

a pipe tap with a total taper of ¾ inch per foot, cut with a chaser supposed to be held in a threading tool-holder. In Fig. 1 a chaser is shown such as would be held in the threading tool-holder made by the Pratt & Whitney Co., this threading tool-holder being the most popular one and the one most exclusively used for ordinary threading. It is evident that if either a single point cutter or a chaser used for ordinary straight thread cutting were put in a holder and the holder swiveled around so as to present the chaser to the work at right angles to the outside of the tapered blank to be threaded, the thread formed would not be correct, inasmuch as a line drawn through the center of the thread perpendicular to the axis of the tap would not bisect the angle of the thread. This last condition, that the line perpendicular to the axis of the tap should bisect the angle of the thread as shown in Fig. 1, is the main requirement for producing a correct thread on a tapered piece. In order to produce such a thread with a chaser, the chaser must be made in a way specially adapting it for this class of work only. There are two



Figs. 2 and 3. Two Methods of Milling the Teeth of Chasers for Taper Taps.

ways in which such a chaser can be made, depending upon the way in which the chaser is to be presented to the work. In the first place, the chaser may be presented to the work perpendicular to the axis of the tap, as shown in Fig. 1, or the chaser may be presented perpendicular to the outside surface of the tap blank as shown in Fig. 4.

We will first discuss the former case. If the chaser were not provided with clearance it is evident that the milling cutter for milling the grooves in the chaser would be a 60-degree angular cutter, being 30 degrees on each side. The chaser would be held in the vise as shown in Fig. 2 and the cutter fed down, for each consecutive tooth cut, an amount depending upon the taper and the pitch of the thread. The values of a (Fig. 1) for pipe thread and other common taper tap pitches are as follows:

Threads per inch.	a
8	0.0039
11½	0.0027
12	0.0026
14	0.0022
18	0.0017
27	0.0012

However, as the chaser must be made with 15 degrees clearance, the milling cutter cannot be made 60 degrees, but must be made 61 degrees 44 minutes, this being the angle between the two sides of a single point cutter with 15 degrees clearance angle, if measured in a plane at right angles to the front face of the tooth. The arrangement for holding the chaser when milling, and the angles required for the milling cutter are shown in Fig. 2. The feeding down of the cutter will not equal a (Fig. 1) on account of the 15-degree clearance angle, but will be equal to $a \times \cos 15$ deg. This distance is shown as b in Fig. 2. The values of b for various pitches are given below:

Threads per inch.	b
8	0.0038
11½	0.0026
12	0.0025
14	0.0021
18	0.0016
27	0.0011

While b is, theoretically, different from a it will be seen by comparing the two tables that the difference is so small as to be insignificant for all practical purposes.

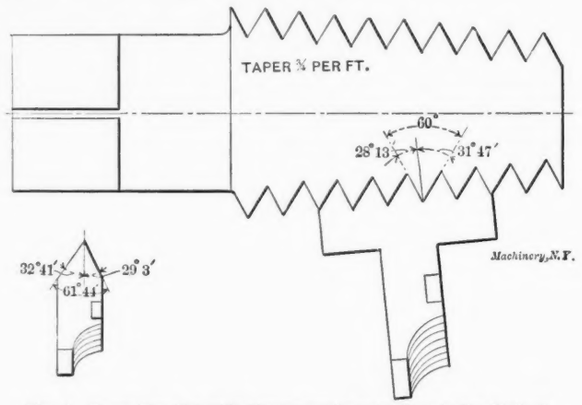


Fig. 4. Taper Tap Cut with Chaser made according to the Method shown in Fig. 3.

We will now consider the case where the tap is cut with a chaser at right angles to the outside tapered surface of the blank. We will find that in cutting this chaser with a milling cutter and holding it as shown in Fig. 3 we will not need to feed down the milling cutter for each consecutive tooth to be cut, but the milling cutter itself must be provided with different angles for the different sides of the thread. In Fig. 4 the actual angles of the sides of the thread with a line perpendicular to the outside surface of the blank are given as 28 degrees 13 minutes and 31 degrees 47 minutes, respectively, the sum of these angles being 60 degrees. The chaser being cut with 15 degrees clearance, these angles in the cutter will be 29 degrees 3 minutes and 32 degrees 41 minutes respectively, the sum of these two angles being 61 degrees 44 minutes. In Fig. 3 the manner of holding the chaser in a vise and the angles of the cutter are plainly shown. In the view to the left in Fig. 4 are indicated the angles to which to plane a single point cutter held in the same manner as the chaser and provided with a clearance of 15 degrees.

Care must be taken when making chasers to be used in the manner indicated in the first case that the elevating screw of the milling machine, by means of which the chaser is raised up toward the milling cutter for each consecutive tooth cut, is correct, and that no back lash enters as a factor in the operation. As this is difficult to insure against, it is advisable to cut the threads according to the second method, as there the chances of error are smaller, it only being required that the milling cutter is ground to the exact angles wanted, and that

the chaser afterward is presented to the work fully perpendicular to the outside surface. The angle which the face of the chaser in the latter case will make with the axis of the tap to be cut is 1 degree 47 minutes. This angle, however, would be difficult to measure unless the threading tool were held in a tool-post provided with some kind of a graduated swivel. In such a case a chaser could be placed so that its face would be parallel with the axis of the tap, clamped to the tool-post swivel, and this swivel afterward moved around in an arc corresponding to 1 degree 47 minutes. Ordinarily, however, if the tap blank is turned to a correct taper, the chaser can be set from the outside surface of the blank, its face being parallel to this surface in a horizontal plane through the axis of the tap.

* * *

A compressed air tank containing 15,000 cubic feet of air, and a dynamite magazine holding four tons of dynamite, exploded at Homestead, N. J., near the mouth of the tunnel the Pennsylvania Railroad is building under Bergen Hill, shortly after midnight, March 4. The tank was used for keeping a supply of compressed air for the tunnel, with which the tank was connected by a system of pipes. The explosion in the air tank, which occurred first, did very little damage except to the tank itself, but the detonation of the first explosion caused the dynamite in the magazine some distance away to explode. The two explosions took place only a few seconds apart and sounded as one, the hill back of the tank acting as a sounding board and causing the sound to be magnified to such an extent that the report was heard, not only in Manhattan, where it shook every building, but as far away as Coney Island and Whitestone, L. I. It is intimated that the probable cause of the tank explosion was improper lubrication in the air compressor. It is well known that the heat of compression may easily exceed the flash-point of cylinder lubricating oil, and if oil is used in quantity the condition is favorable to an explosion in the pipes and receiver. Such accidents are avoided by the use of soap-suds or graphite for lubricating the air cylinder.

A RAPID ACTION HYDRAULIC FORGING PRESS.

As most well-informed machinists are aware, there has taken place in the past ten or fifteen years a radical change in the methods employed in forging heavy work. This change has been, briefly, the substitution of the press for the hammer. With the increase in the size of forgings and in the hardness of the material of which they are made, there has come increasing difficulty in obtaining satisfactory results with the steam hammer. With the most powerful of these machines in use fifteen years ago, it was well nigh impossible to deliver a blow of such intensity that its effect would reach to the center of an ingot of the large size required for the heaviest marine and ordnance work of the period. A blow of ordinary intensity would merely deform the surface of the work; flaws in the center of the material might even be enlarged rather than obliterated. The increasing size of hammer necessary to produce the desired effect in forging reached its culmination in the great 125-ton machine, of which a model was exhibited by the Bethlehem Steel Co. at the Chicago Exposition. This great instrument, however, had scarcely commenced what was expected to be a long life of usefulness, before the process of hydraulic forging was found to be so far superior to hammering that the giant machine was relegated to an inglorious obscurity.

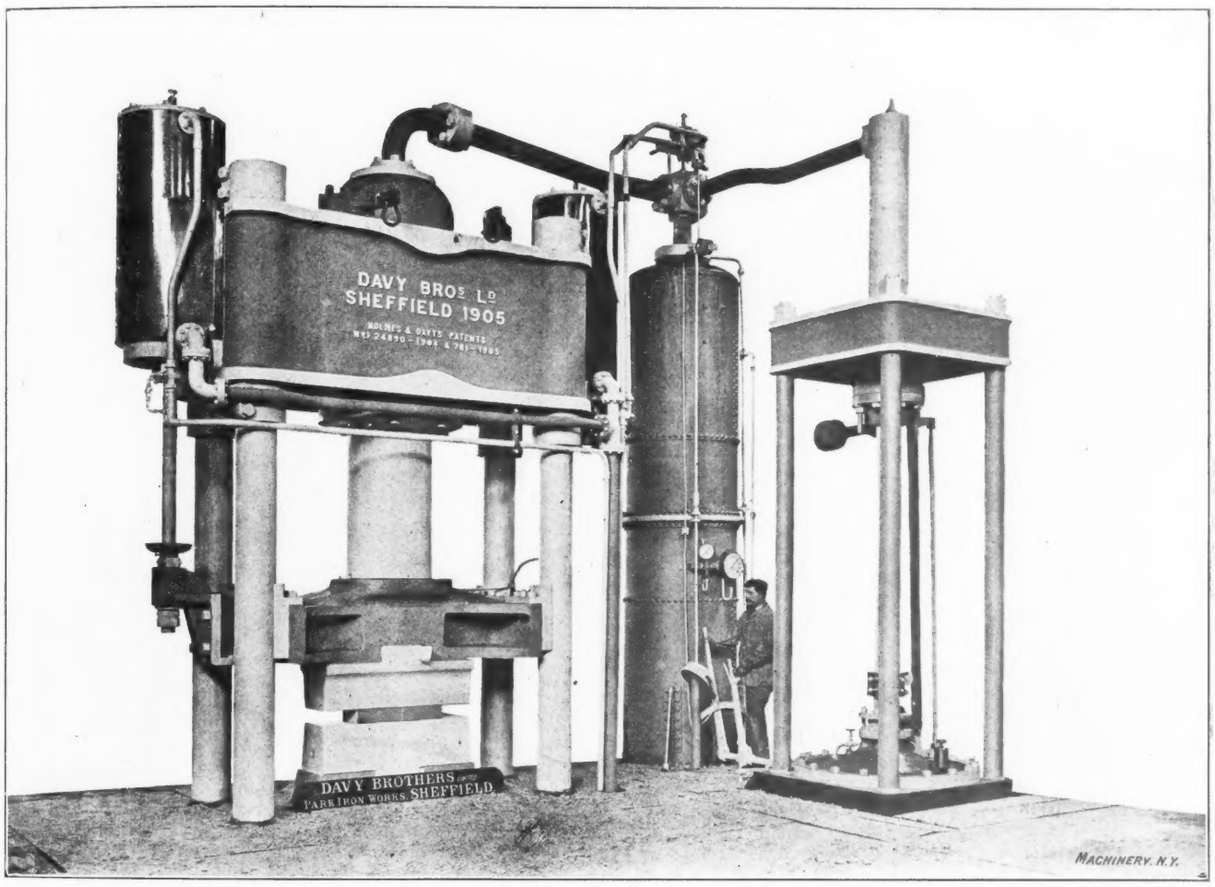


Fig. 1. Forging Press with Rapid Hydraulic Action.

The hydraulic forging press was first applied only to extremely heavy work. On billets and forgings of large diameter, the steady and tremendous pressure obtained from it is distributed through the whole mass of metal clear to the center, bulging out the sides of the work instead of merely making an impression on the surface which came in contact with the dies. This action works the metal throughout its entire volume, closes up all the flaws, and gives to every fiber the toughening effect produced by judicious working. But the slowness of action of the regular hydraulic press limited its use to large work, in which considerable time was of necessity consumed in handling the part being operated on and bringing it into position for a new stroke.

To obtain, on medium-sized work, the benefits of pressure

working as distinguished from impact working, a number of arrangements have been devised for giving a high speed to the ram in raising it from the work and lowering it again, with provision for exerting the desired heavy pressure as soon as the parts are in contact with the forging. Of these various arrangements one of the most interesting is that employed by Davy Bros., Sheffield, England. Applications of the idea to two forms of forging presses are shown in Figs. 1 and 3. The various parts are best seen in Figs. 1, and the line drawing of the same press in Fig. 2. The upper die, *A*, is attached to a cross-head *B* which has bearings on the four vertical tie rods. The hydraulic pressure is applied in cylinder *C*. *D* and *D* are two steam lifting cylinders for raising the ram. *F* is a combined air and water vessel adapted to store the water used in the hydraulic operations, and furnish it to the ram as desired for the quick movements, this being done by displacement due to a moderate air pressure. These operations are controlled by an automatic valve at *E*. *G* is the hydraulic cylinder of the steam intensifier, whose steam cylinder is seen at *H* in Fig. 2, the main part of it being below the floor level in Fig. 1.

The operation of the mechanism can perhaps best be described by following the movements of the operator in making a single working stroke on a forging, starting with the ram in the position shown in Fig. 2 with the dies together. The movements of the press are controlled by lever *L*. The operator first desires to raise the ram *B* for the purpose of inserting the work. Handle *L* is pulled over toward the right. This opens valve *R*, first allowing steam to enter under the pistons in the lifting cylinders *D*. Ram *B* is thus raised, forcing the water contained in cylinder *C* back through pipe *J* into the water end of the intensifier at *G*. When the intensifier ram has been forced downward and the space above it has been completely filled with the returning water, the upward movement of ram *B* would have to cease, did not the operator continue to pull lever *L* further toward the right. This action operates a relay valve at *M*, which, admitting steam under an auxiliary piston *N*, opens valve *E*, thus allowing the water in pipe *J* to escape into the water space of reservoir *F*. This reservoir has a lower compartment containing air under moderate pressure, but the steam in cylinder *D* furnishes sufficient force to return the water to reservoir *F* against the air pressure contained in it. The ram being thus raised for the insertion of the work, the operator returns lever *L* to its central position, when all valves are closed and the parts are in equilibrium.

The work being properly presented to the dies, the operator pushes the controlling lever toward the left. This movement first shifts piston valve *R* and connects cylinder *D* with the exhaust. The weight of the ram and die is thus left unsupported and they descend at the rate of about 2 feet per second, being helped along by the water under pressure in reservoir *F*, entering through valve *E*, which is arranged as a check valve and freely permits movement in this direction. As the die reaches the work, a further movement of handle *L*

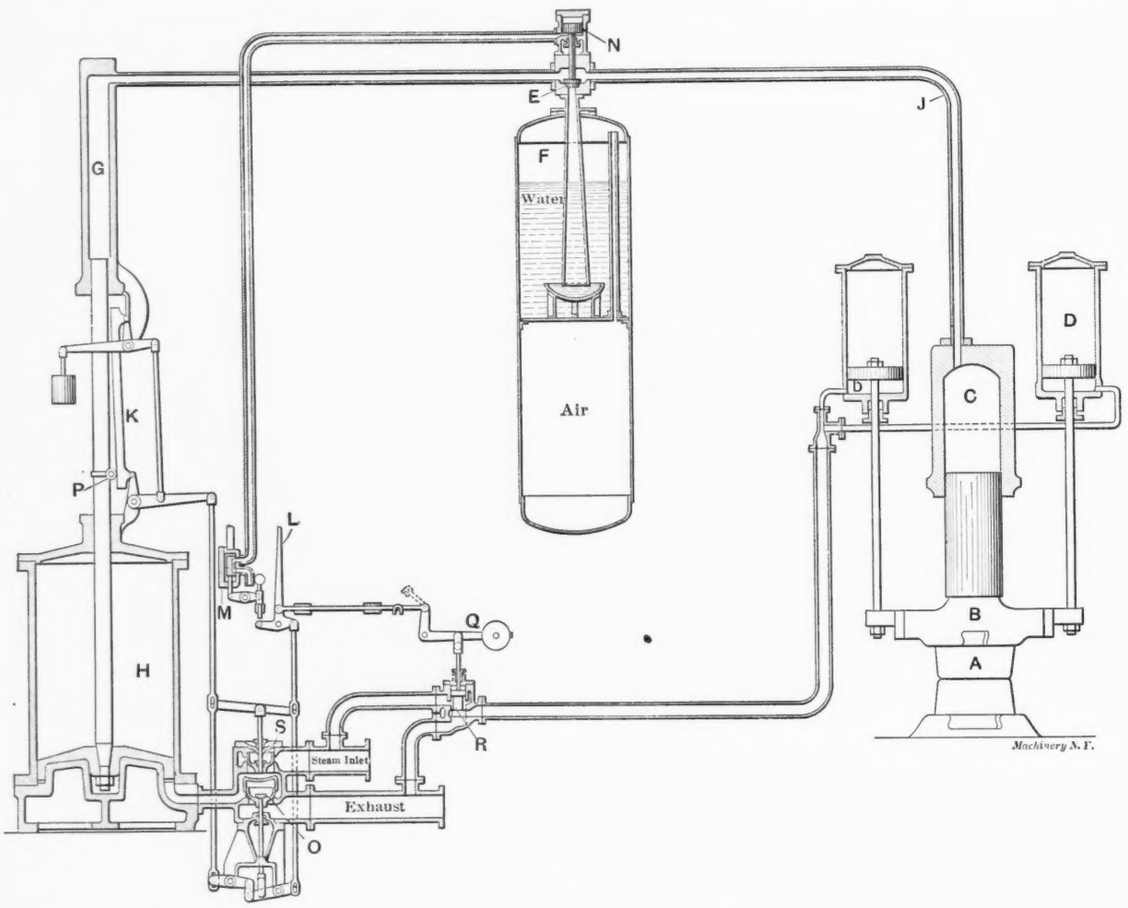


Fig. 2. Diagram of Forging Press in Fig. 1.

to the right, through the connecting mechanism shown opens the balanced poppet valve *S*, admitting steam to the under side of the piston in the steam cylinder *H* of the intensifier. The upward movement of the ram resulting from this, forces the water under tremendous pressure into cylinder *C* of the press, giving the movement and pressure required for the working of the metal.

This movement is under strict control, the length of stroke of the intensifier piston being limited by the amount by which lever *L* has been pushed over toward the left. This governing action is obtained through a floating lever mechanism similar to that used for water wheel governors, steering engines, etc. A bar *K* set on an angle is engaged by a roller *P* attached to the intensifier piston rod. The pushing of lever *L* to the left moves bar *K* toward the roll. As the roll travels up bar *K* it pushes it back again and the pushing back of this bar is transmitted through the floating lever to inlet valve *S* and exhaust valve *O*, operating them in such a fashion as to stop the movement of the intensifier at the desired point.

Provision is made for short rapid strokes under full pressure, for such work as rounding, swaging, cogging down, etc. By means of a lever shown in Fig. 1 at the operator's left hand, the connection between lever L and valve R may be severed. This condition is shown in Fig. 2 by the dotted lines, showing the link attached to the bell cranks raised. Weight Q, under these conditions, drops valve R, keeping the lifting cylinders D in constant communication with the steam pressure. Now if handle L be worked back and forth from the left hand to the central position, steam is alternately admitted and exhausted from the intensifier cylinder, whose piston travels up and down, alternately forcing the ram down and allowing the steam pressure at D to bring it back. Under these circumstances, the water under pressure in reservoir F is not used at all, since handle L is not moved to the right far enough to operate relay valve M. This rapid action brings the press into the same class with the steam hammer for operations of the kind referred to.

For smaller work, that requiring a pressure of from 150 to 200 tons, the single column type of machine, illustrated in Fig. 3, is used. In this the whole mechanism is self-contained as shown, the intensifier being mounted at the rear of the frame, which is hollow and serves as a reservoir for the water

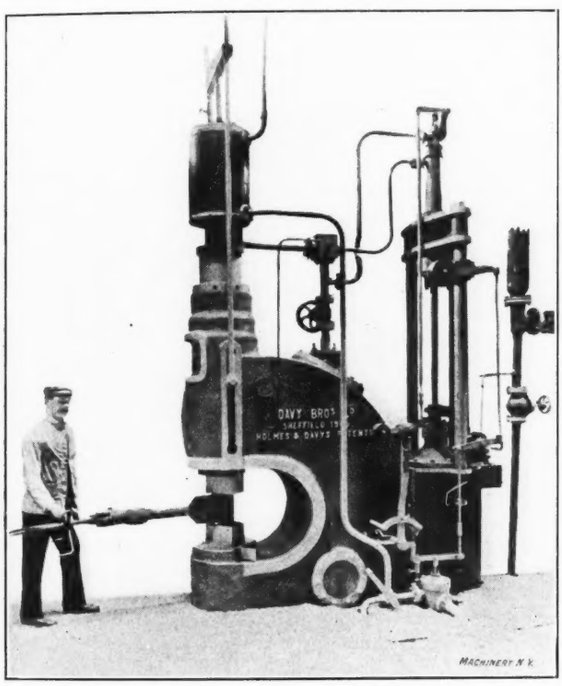


Fig. 3. Smaller Size Hydraulic Action Forging Press.

supply under pressure. The method of operation and the principle of the mechanism are, however, identical with that of the larger presses. The 150 and 200-ton machines will work 6 and 8-inch diameter ingots successfully. For the larger sizes, with the ordinary steam pressure of 150 pounds per square inch and water pressure of 2½ tons per square inch, the size of ingots which can be worked varies from 10 inches for the 300-ton size and 36 inches for the 1,500-ton size, to 72 inches for the 4,000-ton size. The smallest of these machines, working on short stroke, will make 80 strokes per minute with the reservoir F cut out and steam pressure on the raising cylinders as described, and with a machine as large as 1,200 tons, as many as 60 effective strokes per minute may be obtained. This great rapidity of action brings the hydraulic press well within the field of the small and medium size steam hammer. Such presses are somewhat more expensive than hammers of equivalent power, but the additional cost of the foundations for the latter approximately counterbalances this condition, so that the first cost is really about equal. Only about half the steam is required for the press, and it is much less liable to waste through wear and neglect. It has also the great advantage that the breakage of working parts is very small, and the tools can be made lighter and cheaper, and last longer.

NOTES ON ROLLING MILL DESIGN.

B. H. REDDY.

In the May, 1906, issue of MACHINERY appeared an article on "The Design of Billet and Bar Passes," in which was described a method by which such passes could be readily designed. In this article it is the intention of the writer to call attention to some of the conditions which must be taken into account when the design of bar rolls, passes, guides, etc., is undertaken, especially those for continuous mills. In rolling in mills where the piece is passing through from two to ten or more stands of rolls at one and the same time, difficulties are encountered that are not present where the piece is in only one stand at a time. In the latter case the piece is free to elongate, and the rolls can be driven at varying speeds without reference to any of the succeeding passes, while, in the first case, the diameters and speeds of the rolls and the reductions must be correctly proportioned and adjusted to each other.

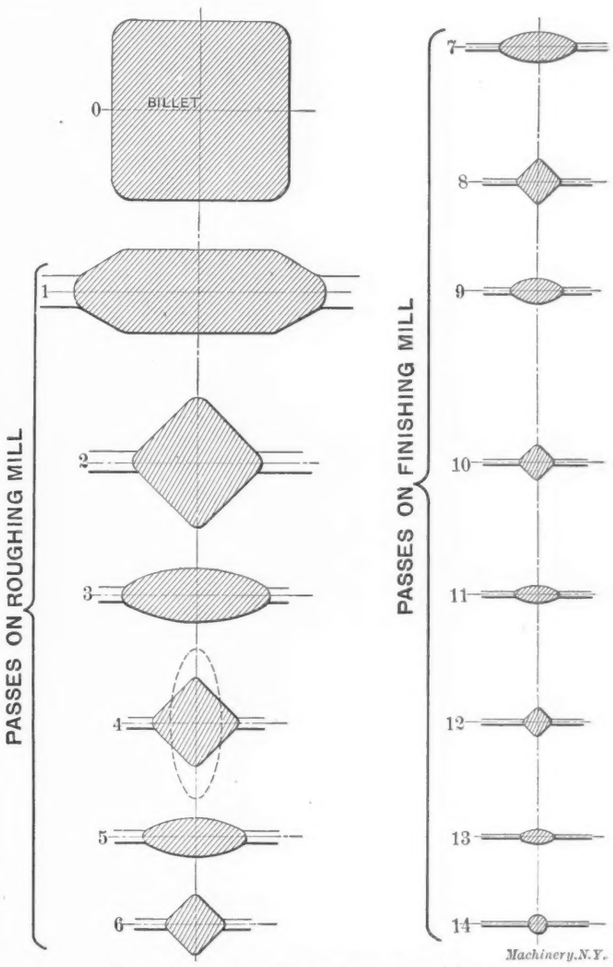


Fig. 1. Layout of Passes for Rolling Round Stock.

As the increase in length of a billet is directly in proportion to its decrease in area, this elongation must be taken care of in various ways. If the piece passes from one stand of rolls into a second stand whose peripheral speed is too great, there must be a slip of the bar between the rolls, or there is a likelihood of its parting if the section be small. Whereas, if the peripheral speed of the second stand be too slow in comparison with the speed of the first, it will cause a bow or loop of ever-increasing length, between the stands. This would cause trouble and could not be allowed. The different stands of rolls on continuous mills, especially on the roughing stands, where the speeds are the slowest, and the reductions the greatest, and consequently the heaviest strains are present, are usually driven by means of gearing from a main driving shaft, while on the finishing stands, where the speeds are considerably higher, the section rolled being small, and the strains comparatively light, belts are frequently used.

After ascertaining the sections to be rolled down and the dimensions of the finished product, the number of passes may be fixed and the same roughly designed. These will then be the basis upon which the proportions of the driving gearing can be designed.

If the exact speeds required cannot be readily obtained by means of the gearing alone, the small discrepancies can be overcome by increasing or diminishing the diameters of the rolls, by altering the reductions or proportions of the passes, or by a combination of both methods. It is apparent that in a mill where the piece is passing through a number of passes at one time, care must be taken in the proportioning of the different parts, so that each pass, diameter of roll, reduction in gearing, etc., will bear the proper relation to the whole. In order that the remaining portion of this article may be more readily understood, a set of bar passes, designed to roll

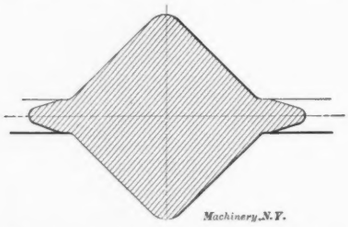


Fig. 2. Formation of "Fins" on Rolled Bar.

down a 1¾ x 1¾-inch billet into a No. 5 wire rod in 14 passes, will be used as an illustration and is shown in Fig. 1. This set of passes was designed for, and is in use on, a continuous rod mill, and may be taken as a typical example of this kind of passes. Referring to the cut, it will be noticed that after the first pass, squares and flat ovals alternate, and the reason why this is necessary will be explained later. In ordinary box passes for the rolling of flats, etc., where the thickness is small in comparison with the width, there is very little tendency for the bar to spread sideways. By a "box pass," is meant a pass where the collar of one roll works in a corresponding groove in the opposite roll, thereby inclosing the pass on all sides. In the style of passes used in the illustrations, care must be taken to design the passes so there will be no tendency for the rolls to choke or to form "fins" on the bar as shown in Fig. 2. These "fins" are frequently the cause of considerable trouble and annoyance, and not infrequently cause the rejection of the finished product. Where a "fin" is

TABLE FOR THE LAYOUT OF THE PASSES IN FIG. 1.

Number of Pass.	Number of Grooves.	Center to Center of Grooves.	Diameter of Rolls.
1	4	3 in.	11.55 in.
2	4	3 in.	11.55 in.
3	4	3 in.	11.95 in.
4	4	3 in.	10.10 in.
5	8	1½ in.	9.80 in.
6	8	1½ in.	10.00 in.
7	8	1½ in.	10.00 in.
8	8	1½ in.	10.10 in.
9	8	1½ in.	10.10 in.
10	16	.8 in.	10.35 in.
11	16	.8 in.	10.25 in.
12	32	.4 in.	10.45 in.
13	32	.4 in.	10.70 in.
14	32	.4 in.	10.55 in.

formed it is rolled back into the bar at the next pass. If this takes place on a continuous mill, unless the fin is too pronounced, it is not likely to cause much trouble, as the distance between the stands is comparatively short, and the bar so well covered by the guides that it has no chance to cool. It is therefore rolled back into the bar without detriment to the finished product. However, on a mill where the bar is rolled backwards and forwards, the last end of the bar out of the rolls being the first into the succeeding pass, the fin has an opportunity to cool sufficiently to prevent welding into the bar properly, and consequently produces a fine crack in the finished bar and causes its rejection. The bar in traversing the short distance between the stands on continuous mills, passes through a guide. This guide is usually of cast iron, flared or chamfered at the entering end, so as to more surely catch the outcoming bar. The opposite, or "delivery" end, closely approximates the shape and dimensions of the bar, and is set as closely as necessary to the rolls and directly in line with the next pass. As before stated, the distance between stands being short, the bar is forced into each succeeding pass, should it for any reason not "bite" at once. This is especially true in the case of the heavier sections. Again, it would not be practicable to produce bars by rolling down only one way; *i. e.*, the bar must be turned frequently through an angle of 90 degrees. In the set of passes accompanying this article, this is required between the 1st and 2nd, 3rd and 4th, 5th and 6th, etc., passes. In mills where the bar is entered into the next pass by hand, no particular attention need be paid to the shape of the section, but in mills where this is to be done mechanically, this must be taken into account. Generally speaking, this is accomplished without the necessity of moving parts, by means of what is known as "quarter turn" or "twist" guides. These are used whenever the bar must be turned before entering the next pass, and differ from the ones previously described, in that they are given a twist, so the bar on being forced through will be delivered in a vertical position, as shown by the dotted lines on pass No. 4. By looking at the passes illustrated, it will be clearly seen that a flat or flat-oval section will be more easily turned by the guides than a rectangular one as the guides can get a better hold upon it. In order to facilitate the removal of "cobbles," as bars are called that have become twisted or entangled in the rolls, guides, etc., these parts are made so as to permit of ready removal. The guides are made in halves, held together and in place by means of key-bolts. The roll-housings are also designed with the same object in view, so that in case of a "mess," the guides can almost instantly be taken out and the rolls raised or taken out without much loss of time. The points mentioned are of prime importance and must not be overlooked by the designer, as a bar of hot steel, driven at a high rate of speed by heavy machinery, can twist itself into a greater variety of shapes and knots, and incidentally, cause more damage and loss of time and tonnage, than an inexperienced person would ever imagine, and the successful designer must have a practical knowledge of the conditions attendant upon the operation and repair of such machinery.

* * *

An American corporation owning a meerschaum mine in New Mexico paints its possibilities in glowing colors in lately published literature, and intimates its willingness to unload 50,000 shares of the $6,000,000 capitalization on the dear public. Aside from this, and constituting the chief interest of the prospectus, to us, is some information regarding meerschaum. The present principal source of meerschaum is Turkey-in-Asia. The Turkish government has a monopoly of the output, and the price, ranging from $40,000 to $80,000 per ton, is steadily increasing on account of limitation of the output. In the dry state, meerschaum will float on water, but soon becomes water-logged. When wet it is heavy and may be cut like butter, but when dry it is the hardest substance in its mineralogical class, offering high resistance to cutting or crushing. It is the best known non-conductor of heat and electricity, and will absorb more nitroglycerine than any other known material. Not long ago it was used only for ornamental work, principally for pipes, but now it is being used for insulation in high-tension electrical apparatus. The high absorptive quality of meerschaum for nitroglycerine makes a new explosive possible which does not give off fumes or smoke, the meerschaum vehicle being far superior in this respect to the present absorbents used in making dynamite. Meerschaum is a valuable material for molds and can be regarded as absolutely permanent, even when subjected to the greatest heat. This, perhaps, is a valuable hint for the construction of molds for alloy castings that shall be absolutely true to pattern.

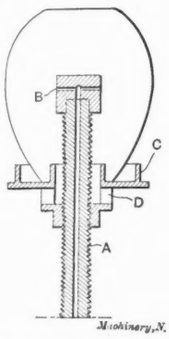
* * *

The Bulgarian authorities have a unique way of settling strikes. Recently the employes of the railways were on strike, and the authorities summoned all the strikers to join the colors, as they all belong to the army reserve. They were then drafted into the engineer corps, and detailed for duty on the various roads.—*Canadian Engineer.*

ITEMS OF MECHANICAL INTEREST.

NOVEL MANTLE FOR GAS BURNERS.

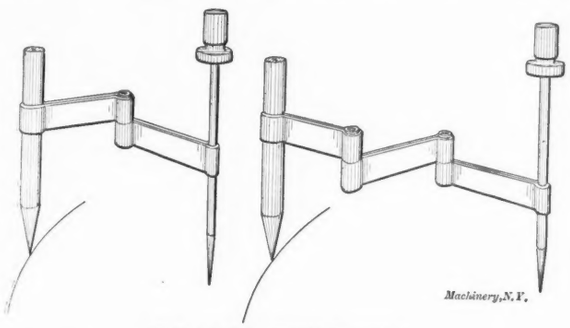
Industritidningen Norden describes a unique mantle, lately patented in Germany, in which the mantle itself consists of nothing else than an egg shell, this being, according to the patent specifications, particularly well suited for acetylene gas burners. The egg shell is converted into a glowing state by means of the combustion of the gas inside, and is said to spread a pleasing and agreeable light. The egg shell does not need any preparation whatsoever excepting the perforation of fairly large holes at both ends, as shown in the cut. Thus, one can oneself manufacture this mantle without any great experience or expense, and there may be a question as to the effectiveness of the patent. Referring to the figure, *A* is the connection to the gas pipe, *B* is the burner itself with small openings on the sides, *C* is a flange provided for holding the egg shell, and *D* the entrance for air.



Egg Shell used as Mantle for Gas Burner.

SIMPLE COMPASS FOR STUDENTS.

In a book recently received from Longmans, Green & Co., New York, was found a circular describing a newly devised pencil compass of very simple construction. It is shown in Fig. 1 in the "two-link" form and in Fig. 2 with the "three-link" arrangement. The first will draw circles up



Figs. 1 and 2. Simple Compass.

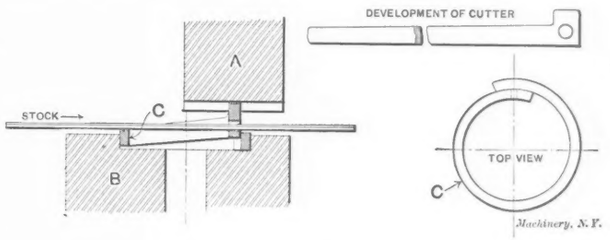
to 5½ inches in diameter, the second has a capacity of 8½ inches in diameter. The construction is so obvious as to scarcely need description. In this compass the pencil and the central stem are always perpendicular to the paper, so that any number of circles may be drawn from the same center without enlarging it to an unsightly degree. There are no screws to get out of order or get lost; an ordinary standard-sized drawing pencil may be used. The device is easily handled and the design is such as to lend itself to the construction of a strong, durable, and accurate instrument at a very moderate price.

NOVEL WIRE CUTTER—AN EXAMPLE OF NEAT DESIGN.

In a certain bookbinding machine it is required to chop off, very rapidly, short lengths of steel music wire. The first thing that would naturally suggest itself for this purpose would be a pair of shear blades, of which the movable one should be held by a sliding member traveling in guides. Other arrangements more or less costly would also be thought of, analogous, for instance, to the wire cutting device described in "J. T.'s" letter in the February issue. The form of cutting apparatus actually used is quite different from either of these, however, and a little thought will show that it is well adapted for the purpose it has to serve.

In the cut, *B* is the frame of the machine and *A* is the lower end of a vertically reciprocating slide which does the cutting. In *B* is a counterbored hole and in this counterbore is seated a cutter *C* of peculiar form, as shown detailed at the right. This cutter is made of a punching in two operations, being blanked and pierced in the first and bent in a partial helix in the second. It is then hardened and tempered, a great number of them being treated at the same time. In normal position the eye, as it may be called, appears above the tail of the contrivance as it lies coiled around snake fashion. When the ram comes down, however, this eye passes behind the tail, and the wire which is threaded through it is thus severed. The projecting head of the cutter is engaged by the slot in ram *A*.

It will be seen that this cutter is exceedingly cheap to make; this is important, for, whether cheap or expensive, its

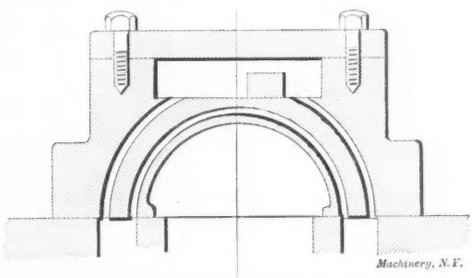


Device for Cutting off Music Wire.

life is a short one owing to the hardness of the material which it cuts. It can at once be replaced by simply lifting the slide *A*, reaching the finger into the counterbore to remove the old cutter, and replacing it with a new one. The wire is then started through the hole of the cutter, and the machine is again ready for operation.

REMARKABLE DEVICE FOR RELIEVING ENGINE CYLINDERS OF WATER.

One of the curiosities of a recent exhibit of safety appliances was a drawing illustrating what purported to be a relieving device for obviating the danger of breakage resulting from the presence of condensed water in the cylinders of steam engines. The accompanying cut is reproduced from a rough sketch which may not be exactly true in its proportions, but will serve to show the design of the appliance. What follows in quotation marks is a reproduction of the inventors specification written on the drawing.



Remarkable Device for Relieving Engine Cylinders of Water.

"The Slide Valve.—This slide valve prevents the cylinder heads from being knocked out when water gathers. When the valve is on its central position as shown, the pressure will be equal on both sides of the piston, thus giving the piston full play and thereby making a safe engine. The compression is adjusted by steam pressure." All of which is indeed illuminating. One's admiration grows as one studies the drawing. It would be interesting to know just what train of thought in the inventor's mind resulted in the production of this remarkable invention.

* * *

According to the *Cologne Gazette*, the widening of the Baltic ship canal will be shortly settled upon. The increase in width is intended to be very considerable, and will provide for the largest vessels afloat. The cost is estimated at $50,000,000, and as the work will involve new locks and drawbridges, it will practically mean a complete rebuilding of the canal. It is estimated that it will require seven years to carry out the enterprise. The progress of shipbuilding is amply expressed in the necessity of this increase of the size of the canal, which was opened only a few years ago, and then was built to provide for the largest vessels afloat at that time, and, in fact, had ample facilities for handling even larger ships.

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MACHINERY

REGISTERED IN UNITED STATES PATENT OFFICE.

DESIGN—CONSTRUCTION—OPERATION.

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MAY, 1907.

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MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages. The Engineering Edition—$2.00 a year—contains all the matter in the Shop Edition and about 250 pages a year of additional matter, which includes a review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. RAILWAY MACHINERY, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

The offices of MACHINERY have been removed to the New York Life Annex, 49-55 Lafayette Street, four blocks north of City Hall and one block east of Broadway. The new offices occupy the entire eighth floor, of which a ten-year lease has been taken, and cover about 6,500 square feet.

* * *

WANTED, A NOISE DESTROYER.

It is a distressing fact that some of our most efficient labor-saving devices are peace-disturbing and nerve-destroying because of the infernal racket they create. The pneumatic hammer, swaging machine, swaging hammer, and most percussive tools are capable of much greater usefulness than they have yet attained, but one cannot consistently wish them to come into general use until some means is invented to mitigate the noise nuisance. The best class of labor is attracted by the most agreeable surroundings and, in turn, light, cleanly agreeable shops breed the best labor in point of intelligence, docility, inventiveness and general resource. The boilermaker, foundryman and blacksmith in mental make-up and disposition are largely what they are because of their forbidding environment. These trades do not attract the best boys, and even if they did, the shop atmosphere perhaps would deaden their better instincts. The machinist is largely what he is because of the more agreeable surroundings of the machine shop and the less arduous toil. If the class of tools which he habitually used were of a noisy, nerve-racking character, the machinist class would be far different from what it is to-day. Hence, realizing the difference that environment makes in a trade, the need of sound mitigators for the useful classes of machinery enumerated in the beginning becomes more apparent. Noise in most machines is to a certain extent unavoidable in the present state of the art, although every machine designer knows that it represents lost work. The perfect machine is that in which the mechanism performs its work silently and without fuss. How such a desirable condition can be brought about in the case of the pneumatic hammer it is impossible to say, and probably it is impossible of accomplishment. But knowing the great improvement that has been made in the pneumatic hammer in the matter of destructive recoil, it may not be too much to hope that the sound nuisance may likewise be greatly mitigated with the improvement of the art.

* * *

THE SAFETY FEATURE OF MACHINE DESIGN.

The American people excel in mechanical ingenuity and the use of machinery in all fields of industrial activity—but this great extension of productive power is obtained at a terrible cost. With the desire to do things quickly and cheaply there has grown up a seeming disregard of life and limb that is appalling when the consequences are realized. The record of the killed and maimed in the United States—all working in peaceful pursuits—equals the casualties of a great continuous war, being over 95,000 for the year ending June 30, 1905, on the railways alone, and more than five times as many in all pursuits for the same year.

Machinery is essentially dangerous, it must be admitted, but its hazard may be so reduced that the roll of accidents would be but a small fraction of the present number, and in manufacturing, *the* way to do it is to educate the machine designers and erectors to keep in mind, always, the possibility of accident and provide against it at every point. Safety of operation should be placed on a par with mechanical efficiency, and our schools of mechanical engineering can do no greater service for the manufacturing industries of this country than to instill this principle into the minds of their young men.

That the proper safe-guarding of danger points is essentially a part of a machine designer's duty is evident to any one who has provided guards for machines built without these features. It is difficult to make such protective devices harmonize with the general design of an existing machine, and not being an integral part of the design they are likely to be taken off if they happen in any way to offend the ideas of the operators. But if made a part of the machine these difficulties disappear. A few months ago we illustrated a foreign milling machine which is an excellent example of correct thought in the matter of protecting all dangerous points, and the general effect is most pleasing. Let us follow this principle in machine design to the fullest possible extent and thus help reduce the present list of accidents to a minimum.

* * *

COMPLICATED MACHINE DESIGNS.

The universal machines which fifteen or twenty years ago constituted the very highest achievements in machine tool design, have proven that the increased complication of their design was fully justified by their added usefulness. The perfected automatic machine which has come to its own at even a more recent date has introduced a still greater complication in the design of machine tools, but has at the same time brought about a production increased to such a degree that we must consider the increase of complicated details, although this as a rule carries with it not only a greater first cost, but also a greater cost of maintenance, as fully justified by the results. The design of complicated machinery may, however, be carried to excess. Some tendencies at the present time to design machines which would be automatic as well as universal, may not, perhaps, be founded on sound economic principles. It is evident that there must be certain limits beyond which further complication in the design of machine tools is not profitable. If the output of a machine can be increased very materially by any new departure, it must be well considered whether the increased first cost of the machine, and the cost of repairs, which usually have to be made by highly skilled labor, do not outweigh the possibilities of increased production.

It seems as if we had now reached the point in machine tool design where increased complication in order to obtain greater results is hardly as important a question as the simplification of our present machines without losing any of their productive qualities. The latter improvement is capable of reducing expenses no less than the former. Designers, as a rule, are very much in favor of complicated and ingenious devices, but as a matter of fact true ingenuity is asserting itself by producing results through the simplest possible means. It is likely that the future will concentrate its efforts no less on this particular point than upon the problems of inventing machines on which almost any operation can be performed at the expense of simplicity and reliability. The best machine tool, and the one which will in the long run give the best satisfaction to the cost keeper as well as to the operator, is the machine which is adapted to perform only one or a few operations, but which can perform its work accurately, quickly, and as far as possible, automatically, at the same time being so simple in construction and operation that it does not require highly skilled labor either for running or repairing.

ONE AIM OF THE AMERICAN INSTITUTE OF SOCIAL SERVICE.

The American Institute of Social Service gave a dinner at the Aldine Club, New York, April 1, to about twenty representatives of the press and various professions. Stereopticon views of safety appliances used in Europe for the protection of industrial workers were thrown on the screen. Dr. W. H. Tolman, accompanying the views with a running description, told about the various permanent museums of security that have been established in Rotterdam, Munich, Berlin, Paris and other European cities. The institute is making a systematized effort to establish a similar museum of security in New York, and it already has a considerable number of models, photographs and other material as the nucleus of such an exposition. These were shown at the recent temporary exposition held in New York at the American Museum of Natural History in February.

Dr. Josiah Strong spoke at considerable length on the need of greater protection to life and men in this country and gave some appalling figures. He stated that as nearly as can be ascertained from our imperfect vital statistics and other sources, 525,000 men, women and children are killed and injured in the United States every year. In the words of President Roosevelt this number of casualties is equal to that sustained in a great continuous war. That is, we are continually killing and maiming as many people in peaceful pursuits as died by shot and shell in the four years of our Civil War, and to that number can be added the number of killed and wounded in both the Russo-Japanese war and our late Spanish-American war. Dr. Strong said that our manufacturers are not, in the main, hard-hearted and insensible to this terrible condition, but they largely lack the means of prevention. If improved devices and ways are pointed out to them by which the number of accidents can be reduced, they are, in general, only too glad to adopt them. In this connection he spoke also of the need of educating young factory inspectors to have an intelligent knowledge of improved safety devices and machine construction which would help to avoid many distressing accidents that are continually occurring. It is of little avail for a factory inspector to go to a manufacturer and tell him that certain of his machines are dangerous, unless he can point out how the defect may be remedied. If an inspector is able not only to point out dangers, but to suggest correctives, his position is greatly strengthened.

It is the aim of the American Institute of Social Service to bring about improved conditions in all branches of industrial activity, including mines, factories, railways, mills, etc., and while the movement is humanitarian, the appeals for improved conditions are made on a strictly business basis. No manufacturer needs to be told that accidents are very costly affairs. Not only may a valuable man be killed or crippled for life, but the effect on the other employes is always bad. Besides all this there may be suits for heavy damages, and the tendency to award heavy damages for industrial accidents is growing. From a political view it is important that the number of accidents be minimized. A crippled man is a pitiable object to others as well as himself. Brooding over his own maimed condition is very likely to make him hate capital and all employers of labor, and become an easy prey for anarchistic agitators. He is much more likely to become a danger to the community through the teachings of demagogues than a man able to earn a good living. A sentiment expressed which evoked general commendation was that we do not need more laws for the protection of labor so much as a lively appreciation that accidents are largely unnecessary and evidences of very poor business policy.

* * *

HOW TO GET ON WITH A SYSTEM.

One of the problems which a draftsman has to worry about, if he works for a big concern, is that of how to get on with the "system." Systems have come to stay. As businesses increase in size and unwieldiness, they cannot be managed by the rules and forms that governed them in the days of their infancy. Hence, we have blanks and forms and regulations and reports and orders, *ad infinitum*. The ideal way to attend to all these various matters is to have that part of the work dealing with the keeping of records, making of orders, etc., done by clerks, rather than by machinists, draftsmen, and others who are supposed to be engaged in more or less "productive" labor. In well-managed establishments there have been found ways to relieve the machinist of most of this worry and drudgery, but, so far, the draftsman has only seen his troubles increase from year to year. Conditions are such, as everyone familiar with the workings of a big corporation knows, that there is a constant procession of men flowing through the drafting rooms. Each day brings its new arrivals with "shining morning faces" eager for the fray, each having high hopes for the pecuniary rewards and increased experience which he is to gain from his new position; but each eve sees the silent and unobtrusive departure of as many battered wrecks who have found that, though competent draftsmen and designers, their nerves were unstrung and their equanimity wrecked by the strain of the pursuit of cross references, and the mad hunt for clerical errors, which the "system" imposes upon the draftsmen of to-day.

Seeing that the "system" has come to stay, he who has to do with it must make up his mind that he will learn to get on with it comfortably. In every establishment there are a few men who are efficient and ingenious designers and at the same time trustworthy and dependable followers of the system. What is the secret of this happy condition? We believe it may be expressed in this simple rule: *Whenever you do this, do also that.* In other words, couple each action, in making a drawing or a change on a drawing, with its appropriate action in relation to the system. Any draftsman knows that it is very unwise to neglect to pick up instantly a tool he has just dropped. He may want to wait until his pen is empty of ink, but before that time he is almost certain to have stepped on his spring compass, as it may be, perhaps, and to have ruined it beyond repair. He must associate the sound of the dropping instrument with the action of picking it up again. In like fashion the draftsman must analyze the system which he is using, and give to each action of his its appropriate clerical counterpart, and associate them in his mind indissolubly. If things are so ordered in the establishment with which he is connected, when he is changing the material of a casting from brass to phosphor bronze, for instance, he must *immediately* make the corresponding change on the stock list, or at least make and pass through the regular channels a note requiring that this change be made. When he has completed the drawing of a new part made from a casting, if his system requires it, he must *at once* make out the corresponding pattern order for having the pattern made. So it goes to the end. A moment's delay, a little folding of the hands to slumber, and the whole thing has escaped him; he is trusting to his memory; some things are forgotten, and some only half remembered. The longer this condition lasts, the more do his troubles pile upon him, until, finally, he finds that his job has run away and left him, and he has become the before-described battered wreck, who, with his bag of tools and reference books under his arm, slinks out of the door as twilight falls, never to return. Some time some wise man will find a way to let the skilled designer do his work with a mind care free from clerical details. Until then, eternal vigilance is the price of safety.

* * *

There are some shop proprietors who think that a foreman should be rushing about the shop continually, and who would at once conclude that he was not earning his money if they saw him quietly sitting at his desk planning out work for the next day or the next week, or even for the next month, as he ought to be able to do where the conditions are as they should be. This planning ahead is one fundamental feature of the Taylor system of works management, only it goes still further and relieves the foreman of the necessity of doing the planning, delegating that function to a planning department. Even the foreman, as he is generally known, becomes a nonentity, inasmuch as his position practically disappears, and is taken up by functional foremen who exercise only one of the many duties now assigned to the ordinary foreman, but that is another story.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

According to *London Answers*, Great Britain prides itself of the most expensive piece of railway ever constructed. On the London Underground, between Trinity Square and King William's statue, the construction cost is $5,000 a yard, which corresponds to $8,800,000 a mile.

The largest steam turbine as yet undertaken, according to *Industritidningen Norden*, is at the present time being built by Brown, Boveri & Co., Mannheim, Germany. This turbine is to develop 24,000 horsepower and is built for the Krupp Iron Works in Rheinhausen, where a steam turbine of 13,500 horsepower already is in operation.

On March 22, the House of Commons of Great Britain, by 150 to 118 votes, rejected the bill proposing to introduce the metric system into Great Britain. The president of the Board of Trade said in behalf of the government that the adoption of the metric system would prove a costly experiment to the country, and that Great Britain would lose the advantage which she possesses in certain foreign markets over her metric system competitors.

Lloyd's Register states that the world's merchant marine was, during last year, increased with about 2,158,000 tons. The increase in Great Britain alone was 764,000 tons, or about 35.5 per cent. If one considers only steamships with more than 3,000 tons displacement, of which in all 389 were built with a total of 1,788,055 tons, counting in those for the Great Lakes, not less than 81.5 per cent were built in Great Britain.

The most remarkable endurance contest for automobiles as yet undertaken, will undoubtedly be that between Pekin and Paris, concerning which the *Horseless Age* gives some information. No less than 18 cars have been reported to enter the contest. These vehicles have been shipped by railroad from Paris to Pekin, from which latter point the cars are to start. The route followed will be that along the Trans-Siberian Railroad, and the participants, who left Paris about April 15, are establishing supply stations along this road on their outward trip.

It is said that Secretary Taft is intending to appoint a committee consisting of architects, landscape gardeners and artists for the purpose of gathering material at Niagara Falls for a report looking toward harmonizing the commercial buildings, particularly the power plants located there, with the natural scenery. Such a step, if practicable, is undoubtedly one of importance, because too little has so far been done in regard to the preservation of the natural beauty of the falls, and too much has been given up to commercial consideration.

In comparing the rates of progress in the boring of large railway tunnels, says the *Mechanical World*, one finds that the Simplon tunnel, 12¼ miles long, was constructed at an average of about 28 feet per day. The Arlberg tunnel, 6⅝ miles long, progressed at the rate of 27.8 feet per day. The St. Gotthard tunnel, 9¼ miles long, was bored at an average of 14.6 feet per day. The 8-mile long Mont Cenis tunnel was built at 8 feet per day, and finally, the Hoosac tunnel, 5 miles long, progressed at the rate of 5½ feet per day.

Wireless messages sent from Washington, D. C., were lately received at Point Loma, Cal., a distance of about 2,400 miles clear across the continent. The messages were intended for Pensacola, Fla., but were distinctly intercepted by the operator at the California station. This is, as far as we know, the first instance in which a wireless message has been transferred across the whole continent, and probably the first instance of wireless messages anywhere having been interpreted after having traversed so long a distance of land.

An interesting experiment in the adoption of automobiles for traction purposes is at present being made in the Congo Free State. There is too little traffic to warrant the building of railroads, but fairly good roads have been built, and motor wagons make daily trips at a speed of about six miles per hour. When considering the slow speed, says the *Horseless Age*, it must be remembered that the road is not the paved street of civilization. If this experiment proves successful, it is intended to cut main roads for these motor wagons over the whole region.

The new terminal station at Hamburg, Germany, is one of the largest railway terminals in the world. The cost of the station and the work connected with preparing terminal facilities has amounted to more than $21,000,000. The main train shed has a span of 240 feet, a length of 580 feet, and a height of 118 feet, and is one of the largest glass-covered spaces in the world, covered as it is by 125,000 square feet of glass. Of special interest is the installation for facilitating the handling of baggage, which is transported to and from the platforms by means of wide, electrically driven, endless link belts.

The *Times Engineering Supplement* devotes a short note to the case of the steamship *Goldmouth*, a vessel which burns liquid fuel and which recently arrived in London after a passage from Borneo, a distance of over 12,000 miles without a stop. This is the third long distance non-stop run made by this vessel while burning liquid fuel, the first being from Singapore to Rotterdam in May and June, 1906, and the second from Singapore to Thameshaven in the fall of 1906. There is probably no other recorded instance of a single vessel having made three non-stop runs of such a distance with any kind of fuel.

A large project is under way for building a dam in the Connecticut River from Coopers Point, Hinsdale, N. H., to the Vermont shore in Vernon, a few miles below Brattleboro. The dam will be built of reinforced concrete on a solid rock foundation and will have an 800-foot spill-way. It will form a lake about eight miles long and a mile wide in places. The dam will develop a fall of 26 feet and it is expected that 12,000 horsepower will be made available for ten hours per day. The cost of the dam will exceed $1,000,000. It is proposed to sell power for local use at $25 to $30 per horsepower per annum.

It is claimed that the Pennsylvania R. R. has increased the efficiency of its freight cars in two years from 16.52 miles per day to 27.19 miles per day average movement. If this increase, which surely is badly needed when the traffic is as congested as it is at present, is due to the policy of the Pennsylvania R. R. to put practical railroad men at the head of its executive departments, it is an ample demonstration of what the railroads in this country will be able to achieve when the practical railroad man comes to his own, and stock jobbing railroad presidents are eliminated from our transportation system.

The *Monitor* first demonstrated the value of the turret in fighting machinery, and the promoters of the peaceful art of machine design were not slow to see its advantage, for the turret in machine construction has been fully recognized. Every year brings forth new machines making use in one way or another of the idea of a revolving turret, and Germany is the country where this idea has been made to serve a practical purpose for theatrical performances. The stage in a new theater in Berlin is placed on a revolving turret so that in a play of several acts, the decorations for each act may be of a more permanent character and, as the play is advancing, at the end of one act the turret will revolve and place the decorations for the next act in front of the audience, exactly in the same way as the turret turns around in a turret lathe, presenting a new tool to the piece held in the spindle.

A note in *Railroad Men* says that the Pennsylvania R. R. is considering a plan to substitute electricity for steam on its suburban lines, and whether the plan will be adopted or not will depend upon the report of a commission sent by the railroad to Europe to investigate electrification on railways there. This commission has recently returned, and it is understood that considerable information has been collected in favor of using electric power within city limits and on short suburban runs. It is understood that the report of the commission will recommend the motor in place of steam in spite of the considerable cost which the change from steam power to electric power for suburban service would involve. The resultant economies, it is declared, would warrant the step.

The electric cable manufacturing firm, Pirelli & Co., of Milan, Italy, whose experiments with high tension conductors we mentioned in our foreign notes in the January issue, are at the present time manufacturing cables which are used for 100,000-volt circuits. These cables are constructed in the following manner. The core of the cable is covered with a lead sheathing, then comes a layer of rubber about 0.100 inch thick, and two other layers of rubber about 0.100 and 0.180 inch thick, respectively. The last layer of rubber is covered with a layer of impregnated paper 0.200 inch thick. Lastly comes a layer of hemp and a lead sheathing which completes the electrical and mechanical covering. The thickness of all the insulated layers is about 0.600 inch thick and the outer diameter of the cable is nearly 2½ inches.—*Electrical Review.*

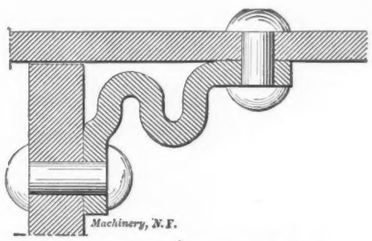
According to *Industritidningen Norden* experiments have been undertaken on the Prussian state railways in order to ascertain to what extent there is an actual saving in the use of superheated steam. There have been doubts expressed as to whether the use of superheated steam actually saves coal at all, because while the amount of steam is decreased, the amount of coal necessary for generating and superheating each pound of steam is increased. These experiments, however, show that there is a very decided saving in coal by the use of superheated steam. The following table gives the average result of the experiments:

Superheat, Degrees F.	Saving in Coal, Per Cent.	Saving in Steam, Per Cent.
68	5	8
104	9	12.5
140	12	16
176	14.5	20.5
212	17	24
302	24	34

The *Times Engineering Supplement* calls attention to the reluctance of large factory owners to rely upon single steam turbines as prime movers for their power equipment. While the advantages of the steam turbine are universally recognized, temporary breakdowns are, it is stated, still unpleasantly frequent. Leading turbine manufacturers therefore prefer to put down at least two tubines, each of half the capacity, instead of one of the full capacity necessary for driving the factory equipment. There will then be a better chance of having some power still available in case of breakdowns. One prominent British firm proposes that where two turbines are installed instead of one, each of them should be designed so that it would be able to operate at 100 per cent overload for at least a full working day of ten hours, so that necessary repairs can be effected on the other machine. There may be doubts as to whether this would be commercially expedient, and the proposed precaution is quite likely to increase the doubts in the minds of nervous buyers of power plants. The breakdown of machinery is a risk that must be expected by the owner of a small private installation, whether rotary or reciprocating engines are employed, but it is natural that the buyer will select that kind of engine which has been found by long usage to be the most reliable. For large power stations, however, where there is a great number of generating sets, there seems to be little doubt but what the steam turbine is far superior to any other steam power generator.

IMPROVEMENT IN LOCOMOTIVE BOILERS.

A French inventor, Mr. C. Frémont, of 124 Rue de Clignancourt, Paris, has patented an improvement for locomotive boilers which is shown in the accompanying cut. As will be seen, the tube plate is connected to the cylindrical shell of the boiler by means of a flexible angle iron, being corrugated or folded as shown. This flexible angle iron yields under the effect of the expansion of the tubes, and the lengthening of



Improvement in Locomotive Boilers.

these is made possible by the spring action of the corrugated plate, which thus relieves the tube plate of the boiler of all unnecessary strains. The angle iron is easily accessible, so that, if for any reason it should become cracked or damaged by the action of the expanding and contracting tubes, the damage can be immediately ascertained, and the angle iron easily (?) replaced.—*Mechanical Engineer.*

A SIMPLIFIED SYSTEM OF COMPUTING HORSEPOWER.

One of the technical writers of the *Horseless Age* has recently evolved a simple formula for the computation of horsepower. It may be expressed as follows:

$$\text{H.P.} = \frac{\text{Cubic capacity of cylinders (cubic inches)}}{10}$$

This simple formula is the result of extensive computations, and until recently it would not have been possible to make so general a statement. The horsepower depends upon the rotative speed of the crankshaft, but within the last year or two it has become almost universal practice to make 1,000 revolutions per minute the normal speed for all automobile engines. The other factors which enter into the familiar old horsepower formula, the mean effective pressure, length of stroke and piston area, are taken care of as follows: Piston area and length of stroke multiplied together give the cylinder volume, and the mean effective pressure will be found to vary but slightly in modern automobile engines, since practically all of them use the same grade of gasoline and approximately the same compression pressure. Therefore the horsepower of a modern automobile engine should be nearly proportional to the cylinder volume. The form of the combustion chamber and position of the spark plugs, of course, control to a certain extent the mean effective pressure; but in practically all cases the arrangement of the combustion chamber is the same, so that no attention need be paid to this matter when once the constant is established by which the cylinder volume is multiplied. This constant, as will be seen from the above equation, is one-tenth, and was determined as the result of a number of tests of various engines.

TRANSMITTING PHOTOGRAPHS BY ELECTRICITY.

Professor Korn of the University of Munich, Germany, has succeeded in designing an instrument for the transmission of photographic images over a telegraph wire. While many inventors have been working on the same subject for years, none has reached as practical results as has Prof. Korn. He uses selenium, as would be expected, as the basis of the instrument, and two motors move a corresponding mechanism simultaneously at the transmitting and receiving stations. The photographic film with the image which is to be transmitted is rolled on a glass cylinder. The cylinder revolves slowly and at the same time moves longitudinally. A ray of light from an electric lamp is made to pass through the film and the glass cylinder through a small hole in the front of the latter, and on account of the motion of the cylinder every point of the picture will be exposed to this ray of light. The

light, after having passed through the image is reflected upon a selenium cell, and according to the light or dark parts of the photographic film, the beam of light falling upon the selenium cell will have a greater or less intensity. These variations of light cause a corresponding variation in electrical resistance of the selenium cell, and as the latter is connected with a line through the batteries, a variable electric current is sent over the wire to the receiving station. The apparatus at the receiving station resembles the transmitting apparatus in many respects. We have here, also, a cylinder with a film moving exactly like the transmitting cylinder. The light thrown on this film through a small hole in front of the cylinder is modified in strength, by the variable electric current, by means of a galvanometer. This latter instrument, in fact, is the most original improvement of the Korn system. By the variations of light secured by the varying actions of the electric current on the galvanometer, an image like the original is produced on the film.

STEEL VERSUS WOOD.

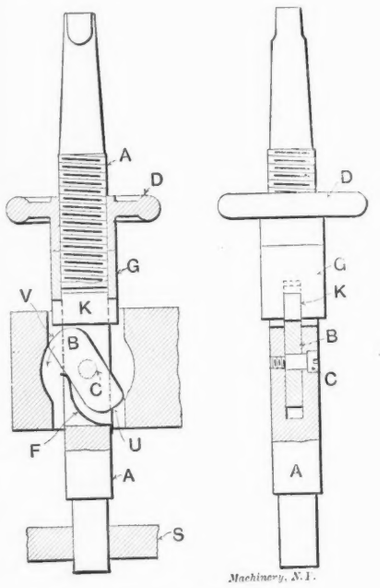
Iron Age, February 14, 1907.

The advance in the price of wood during the recent years has been so great that at the present time steel is cheaper than wood for structural purposes where heavy loads must be sustained, and if the constant, never receding advance of pine is to continue, as lumbermen predict it must, the time is not far distant when steel will be cheaper for all buildings requiring the strength that makes desirable the use of one or the other of the two materials. It is true that when the Panama Canal will be completed it will bring the Oregon and other Pacific coast timber closer to the markets of the middle and eastern parts of the country. A change in tariff relations with Canada may result in timber from our Northern neighbor being imported free of duty. But even then it is not likely that wood will fall very materially in price, and steel will probably even then prove cheaper for many purposes. To exactly compare the cost of steel with that of pine for structural purposes, two examples may be given. In one case a bay of a factory building 10 feet between beams and 20 feet span is to be supported by a beam either of steel or Southern pine. For the sake of convenience a standard 20-foot, 65-pound beam may be taken as a basis. The cost of this beam in a New England city would be $39.00. To attain the same strength with Southern pine under identical conditions, a beam 16 inches deep and 28 inches wide would be required, which means two 14 x 16-inch girders, the cost of which would be $41.00. Thus the steel would have $2.00 the better in the comparison. Taking a smaller size, however, say a 15-inch, 42-pound beam, the cost of the steel would be $25.20, as compared to $20.50 for the equivalent timber—a 14 x 16-inch girder. Taking everything into consideration, therefore, including the expert opinion of men well informed in the lumber business, there would seem to be little doubt that the tendency to substitute steel for wood in heavy mill or factory construction will constantly increase, not only because of the merit of steel as a building material, but because of lessened actual cost.

SIMPLE DEVICE FOR SPHERICAL BORING.

Zeitschrift für Werkzeugmaschinen und Werkzeuge, March 15, 1907.

When inside spherical surfaces have to be produced, the devices usually employed are more or less cumbersome. For this reason the device in the accompanying cut is greatly interesting, because it shows a very simple means of accomplishing what is generally considered as a more or less difficult job. The device shown can be used on the drill press as well as in the lathe. It is cheap and consists of very few parts. As shown in the cut the tool is intended for use on the drill press. When used in the lathe the tapered shank is done away with, and the spindle *A* is placed between the centers of the lathe, held by a dog in the same way as an arbor. The device consists of a spindle *A*, with a slot cut through it, in which is placed the cutter *B*, which is free to turn around its center stud *C*. A spring *F* holds the cutter in a vertical position so that one can pass the tool in through a drilled hole to the center of the work in which a spherical surface is wanted to be produced. At *S* is shown the table of the drill press itself through which is drilled a hole guiding the lower end of the spindle. Part of the spindle *A* is threaded, and on this part is mounted a small handwheel *D*. The thread on the spindle is left-handed. When the drill spindle turns, carrying with it the spindle *A*, the handwheel *D* is fed downward by slightly retarding its motion when turning with the spindle. When the handwheel feeds downward it presses on bushing *G*. This bushing in turn is fastened to the hardened steel key *K* which is also placed in the slot provided for the cutter, and which by the feeding downward of the handwheel *D* and the bushing *G* will press on the rounded corners of the cutter *B* and thereby turn this around its central pivot, forcing it gradually downward and thereby causing it to produce a spherical surface. The cut commences at the top at *V* as well as at the bottom at *U* at the same time, and the spherical form is completed when the cutter stands in a position nearly at right angles to the axis of the spindle. It is of course of importance that the cutting edges of the cutter are exactly the same distance from the central pivot *C*, as otherwise there would be a small ridge left in the center of the spherical surface.



Device for Spherical Boring.

VALTELLINA ELECTRICAL RAILROAD.

Teknisk Tidskrift, March 9, 1907.

Probably the first main line in the world using electric power exclusively for the regular traffic on long distance is the Valtellina Railroad in Italy. The electrical installation was carried out by Ganz & Co., Budapest. The current is three-phase alternating; the line has two parallel overhead wire conductors and has the third phase carried in the rails. The length of the road is 67 miles, of which 30 per cent is in tunnels, and nearly 50 per cent of the full length of the road is composed of curves. The maximum grade is 2 per cent, and the minimum radius is 1,000 feet. The road is laid with 80-pound rails placed on impregnated wooden ties, the rails being bonded with copper at the joints to provide for good electric conduction. The electric locomotives weigh 51 tons and have four motors of 150 horsepower each, using current of 3,000 volts. The ordinary passenger trains consist of one motor car and four to five ordinary passenger cars. The speed is from 40 to 45 miles an hour, which is maintained even on grades up to 1 per cent. The locomotives in freight traffic pull trains of 280 tons with a speed of 40 miles per hour, and 440-ton trains with a speed of 22 miles per hour.

The energy necessary per ton mile has been found to be with full speed on the level from 18 to 20 watt hours and in heavy grades from 34 to 55 watt hours. When starting a train to a speed of 40 miles per hour during a time of 2 minutes, about 150 watt hours per ton of train weight is necessary. The average energy required measured at the power station is 73 watt hours per ton mile, but in this is included all current used for heating, lighting, for the power required for the railway shops and all losses. At the power station the maximum load is nearly 2,000 KW. but the average load is only 700 KW..

or slightly more than 1/3 of the maximum. The cost for the electrical installation is shown in the table below:

Power station	$600,000
Main conductors and transformers	200,000
Working conductors	360,000
10 motor cars, each $24,000	240,000
5 locomotives, each $20,000	100,000
	$1,500,000

The cost per mile is thus about $22,400 for the electrical installation alone. The operation costs for 1904 amounted to $300,000. The passenger fares are those common for express train service in Italy, which is 1.6 and 3.8 cents per mile respectively for third and first class. This installation is particularly interesting as it has proven the practical possibility of using the same train system for electricity as for steam on comparatively long distances. It has proven that electrical locomotives in all respects may replace the steam engines, and that the future of electricity for railroad power generation wherever the power can be had cheaply, that is, where waterpower is available, is secured.

ANALYSIS OF QUALIFICATIONS FOR PROMOTION.

The habit of analyzing every problem, separating it into its component parts, is one that distinguishes the thorough-going man from one who merely guesses at things. It is astonishing, to one who has not made it his habit to enter into analytical consideration of every problem presented, how readily some question of apparently complex state may resolve itself into simple parts when subjected to analytical inspection. And that a system of analysis can be applied to an individual, measuring his general ability and fitness for a position has some elements of novelty, even for the habitual analyst. In an article on measuring fitness for promotion by Mr. Joseph L. Gobeille in the *Iron Age*, the accompanying table is given by which a man can analyze his own or others' fitness or unfitness for a position. Of course the values assigned for the various items may not coincide with the individual ideas, but they will serve as a guide in the matter of analytical estimate of an individual. Mr. Gobeille says that in the United States there are literally thousands of openings for assistant superintendents, foremen, assistant foremen, and gang bosses, especially in Eastern and Southern mills and shops. These places pay from $1,000 to $3,600 per year, and besides the salary they carry with them very agreeable emoluments such as private office, stenographer, etc. The man whose ambition is to rise in the world will find the habit of analysis of the greatest value, and if he will apply it to his own case and see how well he lines up for promotion, it may result in strengthening some of the weak parts. In referring to the assignment of values to the various items, Mr. Gobeille says that from personal observation and actual data carefully noted for more than twenty years past, he believes that the nomenclature and division of qualities is sufficiently accurate to be used as a measure and may be safely followed:

a Practical knowledge of the trade, including ability to plan original work and lay down necessary drawings.	25
b Executive ability and initiative	20
c Abstinence from rum, beer and cigarettes	15
d Punctuality and prompt action	10
e General information and versatility	10
f Under 40 years of age	10
g American nationality	5
h Affiliation with some church	5
	100

HEAT LOSSES IN DRYING PROCESS.

In apartment drying where the material remains in the same position during the entire process, variation in treatment is secured by changing either the air volume or the temperature. The discharge temperature is then practically the same as that throughout the room. In the progressive plan, the air supply and temperature remains practically constant, while the material continually progresses from the cooler and relatively more moist portion of the room to that which is hottest and dryest. Under the conditions presented by either system there is a three-fold loss of the heat originally imparted to the air. First, that required to evaporate the moisture in the stock; second, that lost by transmission through walls and by leakage to the outer atmosphere; and third, that carried away in the air intentionally discharged from the room. The first, which measures the actual cost of drying only, is evidently an inherent part of the process and therefore cannot be reduced; the second, which is usually great, depends upon the character of construction, and in most cases could and should be materially reduced; the third loss is to a certain extent inherent, but may be kept at the minimum by maintaining the proper relations between air volume and temperature and the space occupied as the drying room, so that the utmost available drying capacity shall be utilized.

The conditions are clearly shown by the following results of a careful test of a special form of drying tower for removing the moisture from heavy cardboard. It was well built of brick; heated air was supplied under pressure by a Sturtevant steam hot-blast apparatus, consisting of fan and heater, and a portion of the air was returned through a galvanized iron duct and reheated in connection with a moderate supply of fresh air admitted from the atmosphere.

LOSSES OF HEAT IN DRYING SYSTEM.

Source of Loss.	Per cent of Total Heat
Required to vaporize moisture in stock	32
Lost by leakage, radiation from tower and unaccounted for	37
Lost by radiation from return duct and by introduction of fresh air at fan room	31
Total heat imparted to air	100

A portion of the heat was saved by using the return duct, as is possible under proper conditions, thereby cooling and condensing some of the moisture out of the air, and then passing it to the heater at a temperature considerably higher than that of the atmosphere. Had all of the air been discharged from the top of the tower, this loss would have been greater and the efficiency lower, but the higher the tower the better the opportunity of cooling the air to the lowest practicable temperature.

It is easily possible, particularly in a progressive dry room, to make the mistake of having the length of transit of the air over the material so great that the air, although saturated to only 70 or 80 per cent humidity at a relatively high temperature in the warmer portion of the room, becomes cooled below the dew-point before exit, and actually deposits moisture upon the material which is to be dried. Large volumes of air and shorter length of transit will overcome the difficulty.

STEEL RAILS AND THE PASSING OF THE BESSEMER PROCESS.

The Times Engineering Supplement, February 13, 1907.

The fact that the Bessemer process has already passed the zenith of its growth is one which has now become well recognized by metallurgists generally. In Great Britain the open-hearth processes of steel production have, as regards the yearly make, far outstripped the Bessemer process. Taking the British Iron Trade Association's published returns for the first half of the year 1906, it appears that the make of Bessemer steel is considerably less than half of the make of open-hearth steel. There are three main causes for bringing about the supersession of the Bessemer process, which at one time was justly considered to be the most perfect solution possible with reference to the problem of converting crude molten pig iron into steel. These causes are in the first place the growing scarcity of iron ores suitable for the Bessemer process; secondly, the superiority of the product obtained by the open-hearth process, and finally, the cheapening of the production of steel ingot made possible by modern methods. As regards the increased scarcity of iron ores suitable for use in the Bessemer process this is probably the most important of the three causes mentioned. The main English supply has for years been Spanish red ore from Bilbao, but this is yearly becoming both scarcer and poorer in quality. In the United States, apart from the Southern States and the northern portion of New York State, there are practically no ores available for the manufacture of pig iron suitable for the basic Bessemer process. The acid Bessemer process therefore reigns supreme, and there is a strong

rivalry between this process and the open-hearth. In Germany the basic Bessemer process takes the lead over other processes, but nearly 3,500,000 tons were made by the open-hearth process.

The Bessemer process, which is perhaps the cheapest, requires a special quality of pig iron and this quality is tending to become dearer. The waste of metal in the Bessemer process must of necessity always be higher than in any form of open-hearth process. This fact accentuates the importance of the question of the cost of pig iron. The higher the price the greater the cost due to waste. There can be no doubt that the transfer of the Hill ore lands to the steel corporation must tend in the long run to increase permanently the price for pig iron in the United States, and as the margin for economies in the Bessemer process is less than that of the basic open-hearth process, when pig iron becomes too high, the latter process will undoubtedly come more in the foreground. In regard to steel rails this will be quite significant. The 100-pound per yard rail in the United States does not give the satisfaction which the lighter section rail does, as the breakage has proven to be more serious since greater duty has been demanded, following the use of heavier rolling stock and increased tonnage carried. The basic open-hearth process with its higher carbon and lower phosphorus gives a rail greater reliability and better wearing qualities. In the course of the next two years rail plants in the United States will be able to turn out large quantities of basic open-hearth rails in excess of what they are doing already. Canada is at present making open-hearth rails for her own use. England has already two rail mills making use of this process, and probably Germany will soon also adopt it for rails.

It appears, therefore, that unless large deposits of pure ore are found, and are continually developed to keep pace with the increased consumption of iron all over the world, the cost of Bessemer iron will go up, and the manufacture of rails by necessity will pass back again to the open-hearth process. It will seem strange, when this actually comes to pass, that steel rails, which were first made by the open-hearth process, should again be produced in this way after the original process had so long been ousted by the Bessemer process.

THE USE OF KEROSENE OIL IN ENGINES BUILT FOR GASOLINE.

H. B. Maxwell in *International Marine Engineering*, December, 1906.

The constantly increasing demand for gasoline, owing to new fields for its use being rapidly developed, has caused a steady increase in price, which makes the use of the heavier

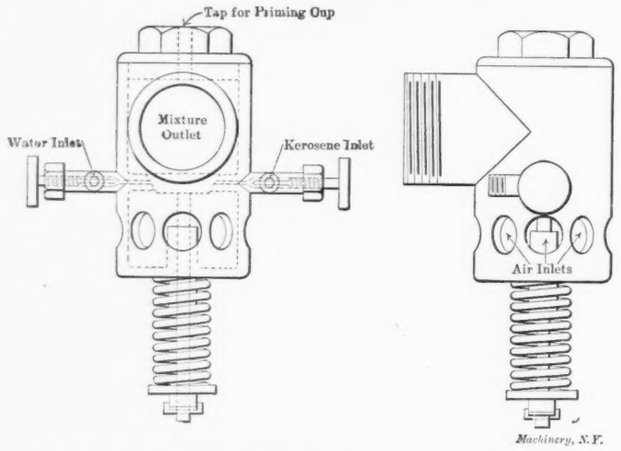


Fig. 1. Mixing Valve for Kerosene Oil used in Gasoline Engines.

and cheaper liquid hydrocarbon fuels a matter of such importance that it has for some time past attracted the attention of engineers engaged in designing internal combustion engines. Kerosene can be used in many engines after being warmed up on gasoline, but not economically unless some device is added to insure perfect combustion of the fuel or to aid in the better vaporization of the fuel before it reaches the combustion chamber. It has been found that by using a common mixing valve of the type shown in Fig. 1, kerosene can be used successfully.

Referring to Fig. 1, it will be noticed that the nut forming the cap to the body of the valve is tapped for a priming cup. This is to be filled with gasoline, and the engine started on this. As soon as the engine is heated up a little, the needle valve controlling the kerosene inlet is opened. After doing this a blue smoke will be noticed at the exhaust pipe. The

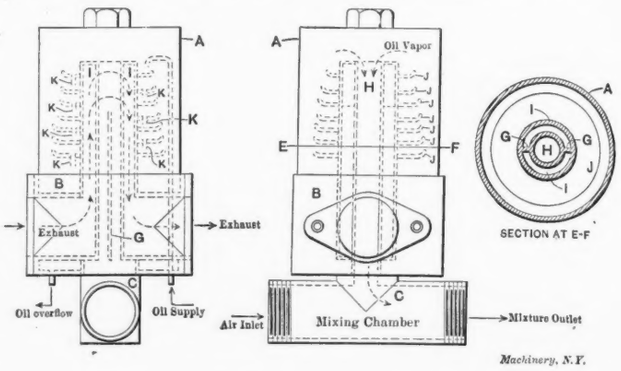


Fig. 2. Kerosene Oil Vaporizer used in Gasoline Engines.

valve controlling the water supply is then turned on, a little at a time, until this smoke clears away. This valve will work on most four-cycle engines using high compression.

Fig. 2 shows an exhaust heated vaporizer that can be used with any engine. It consists of a body *B* and *C*, cast integral with the pipes and oil pans, as shown by the dotted lines and in the section. The cap *A* screws into the body *B*, and can be readily removed to clean the pans of any tar or coke deposited from the fuel used. The oil supply may be operated by a variable stroke pump controlled by a governor, or the engine can be controlled by throttling the mixture between the vaporizer and the intake valve. There must be an air regulator attached to the mixture chamber *C* at the end opposite from the end used to convey the mixture to the engine.

The exhaust enters the T-shaped pipe *I I* and impinges against the pipe *H* and the guides *G G*, giving the exhaust

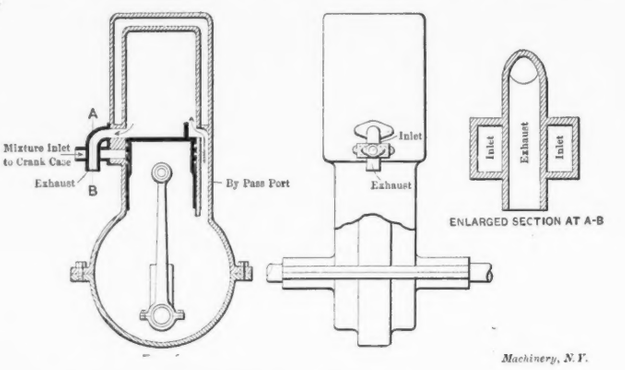


Fig. 3. Kerosene Oil Vaporizer.

gases the course shown by dotted arrows in the view to the left. This imparts part of the heat of the exhaust gases to the walls of the pipe *I I* and the pans *J J*. It will be noticed that the overflow pipes *K K* from each pan to the one next below it, bring the fuel not vaporized by the first hot surface into contact with other hot pans, to complete the vaporization. The oil, gas or vapor flows down pipe *H* to the chamber *C*, where it is mixed with the proper amount of air to furnish the correct mixture.

Fig. 3 shows a device in which the exhaust and intake pipes are cast integral. The inlet from carbureter at the left opens directly against the hot walls of the exhaust pipe, and, as shown in the small sectional view, divides and passes around the exhaust pipe and enters the port to the crank case. To start a two-cycle engine with this device, it must be primed with gasoline, the priming cup being located on top of the cylinder; or the combination exhaust and inlet pipe could be heated with a torch.

ON THE ART OF CUTTING METALS.—5.*

FRED. W. TAYLOR.

FORGING AND GRINDING TOOLS (Continued).

Undoubtedly one of the most economical shapes for tools, when both dressing and grinding costs are considered, is that shown in our standard tools, Figs. 16 to 21 (March issue).

In examining these tools it will be noted that in the 1-inch tool (Fig. 44), for instance, the cutting edge is 1 3/16 inch above the top of the body, and if we assume that 3/64 of an inch of metal ground off from the height of the tool will be sufficient to sharpen the cutting edge on an average, it is evident that a tool of this shape can be ground 24 times before the corner of the emery wheel begins to cut into the body of the tool. If after this we continue to grind the tool, there will still remain as many grindings on this tool as upon the tool, Fig. 26 (March issue), before the wheel shall have ground down into the body of the tool for a sufficient depth to weaken it. Thus it is clear that our standard tool has a shape which permits it to be reground from three to five times as often as the ordinary shape.

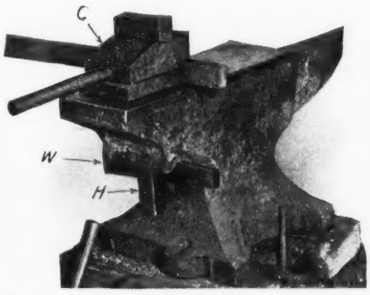


Fig. 31. Tool Cut Off and Clamped to Anvil ready to be Bent Down.

Fig. 32. Cutting Roughly to Proper Lip Angle.

Fig. 33. Heel of Tool being Drawn Down under Steam Hammer.

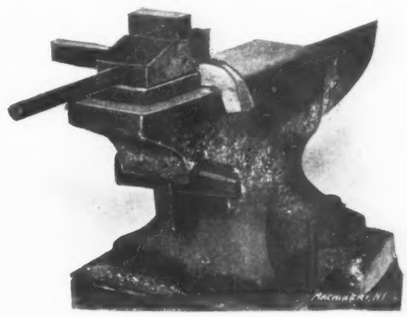


Fig. 34. Tool Bent Down across Edge of Anvil.

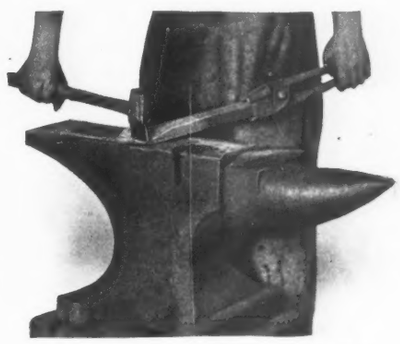


Fig. 35. Cutting Front Corners off the Nose.

The Best Method of Forging a Tool is to Bend or Turn Up its End.

In dressing these tools the end of the piece of steel to be made into the tool is bent or turned up by sledging it down across the corner of the anvil. Figs. 31 to 42, inclusive, illustrate one method of doing this work. It is of interest to note that after the steel from which the tool is made has been cut to the required length and properly marked for identification, these tools up to and including tool steel of 1 inch x 1½ inch can be completely dressed by a good smith and his helper ready for grinding in two heats, provided a small steam hammer with plain flat dies is available for striking the tool a few blows at the proper time; also that without a steam hammer, each tool can be readily dressed with three heats by a smith and one helper or in two heats by a smith and two helpers, the two helpers being required for only a part of a minute.

Bad Practice to Nick the Bar or Tool Steel and Break it off Cold.

The practice of nicking the bar of tool steel with a cold chisel at points corresponding to the proper length of the tool, and then breaking it where nicked by a blow of the sledge on the anvil, is on the whole unwise, as not unfrequently almost invisible cracks are started which may only fully develop after the tool is in use. In cutting to length with a "hot chisel" a low heat is sufficient and the same heat can be used for stamping the rear end of the tool for identification. The following are the steps to be taken in forging the tool after it has been cut to length from the bar.

Heating the Tool.

A. Heat the tool rather slowly so as to insure uniform heating to the center of the bar, turning it over several times while in the blacksmith's fire. The proper heat with the modern low carbon, high tungsten and chromium steels is as high a heat as can be used without causing the steel to disintegrate or fly to pieces when struck with the sledge. Contrary to all former laws and traditions in heating tool steel, this type of steel is not injured by heating beyond a cherry red in dressing, provided the tool is finally heated to the high melting point according to the Taylor-White process. The proper dressing heat varies according to the chemical composition of the tool steel, but is in most cases from a yellow to a light yellow heat corresponding to a temperature of 1800 degrees F. to 1900 degrees F.

In the case of a tool 1 inch in the body, this yellow heat should extend 5½ inches back from its point, and in the following description the dimensions given will be understood to refer to a tool of this size.

When several tools of the same shape are to be dressed at the same time, it is best to heat them slowly in lots of, say, four to six tools at a time; the part of the tools to be heated is brought closer and closer to the hot portion of the fire as they are gradually warmed up, while the one particular tool which is to be forged next is kept directly over the hottest part. A clear coke fire, made and kept sufficiently deep to measurably prevent the blast from coming directly in contact with the tool is, on the whole, preferable to the ordinary soft coal fire used by blacksmiths. This is only true, however, because it is, on the whole, easier to get a uniform fire with coke as the fuel than when coal is used in a blacksmith's fire. Experiments have shown clearly that if sufficient care is used, a first-class soft coal fire oxidizes, and therefore injures the tools less than a first-class coke fire.

Bending or Turning Up the Nose of the Tool.

B. Clamp the tool down hard on the top of the anvil, as shown in Fig. 31, by drawing down the clamp *C* by means of the wedge *W*, the upper edge of which presses against the

* Abstract of paper presented before the American Society of Mechanical Engineers, December, 1906.

lower side of the anvil, and the lower edge against the end of the slot made in the shank of the clamp *C*, which passes down through a square hole in the anvil and projects below the underside of the same. The tool is clamped so that 2⅜ inches of its end project beyond the edge of the anvil.

C. The blacksmith and his helper, each working with a sledge, bend the heated end of the tool down into the position shown in Fig. 34. (The exact shape of tool as thus bent over is shown in Fig. 37.)

A gage similar to that shown in Fig. 36, should be mounted close to the blacksmith's anvil, so that he can readily test the bending of the tool to secure the proper clearance angle. This

Fig. 36. Trying Tool against Cone Gage.

gage consists of a small surface plate with a hole drilled near one corner, into which are fitted a series of cones turned to different angles, corresponding to the various shapes into which the tools are to be bent. The tool without removing the tongs is placed with its bottom surface on the surface plate and the clearance surface against the tapered cone, where at a glance the blacksmith can see whether he has bent it to the correct angle. A similar clearance gage should also be mounted close to the tool grinder so that the clearance angle called for in grinding can be quickly and accurately measured by the operator.

Drawing Down the Heel of the Tool to Secure Good Bearing.

D. The wedge *W* of clamp *C* is then loosened with a hammer, and the tool quickly removed to the steam hammer with flat dies, where the curved portion at the heel of the tool is placed, as shown in Fig. 33, upon the edge of the die, and drawn down with a few blows of the hammer so as to flatten it into a wedge shape. This flattening spreads the metal out laterally until what was a rounding corner becomes almost a right angle; thus extending the flat surface of the bottom of the tool further forward, so as to furnish a support almost under the cutting edge. (The tool in this condition is shown in Fig. 38.)

In case no small steam hammer is available, the heel of the tool is flattened in a similar manner by sledging upon the blacksmith's anvil.

Cutting Off Corners of Nose of Tool so as to Save Work in Grinding.

E. The tool is placed upon the edge of the anvil, as shown in Fig. 35, and its two corners are cut off with a chisel so as to make its nose approximate to the proper curve. The bottom of the heel of the tool is also trimmed off, if necessary, so as to make it flush with the bottom of the tool. The height is then marked with soapstone or a nick of the chisel upon the nose of the tool for cutting to the proper lip angle, and the tool is returned to the fire for its second heat.

It should be noted that operations *B*, *C*, *D* and *E* are all done with a single heat. If, however, at any stage in the process, through lack of skill or unusual delay, the tool is cooled to below a light cherry red, corresponding to a heat of 1550 degrees F., no further forging should be done without reheating.

Cutting to Correct Height and Lip Angle.

F. After slowly and thoroughly reheating the tool, the upper portion of the nose is cut, as shown in Fig. 32, to the proper lip angle, care being taken to secure both the correct angle and height called for. The use of a specially designed hot chisel or set, as shown in this cut will help the blacksmith in this operation.

Bending or Setting the Nose of the Tool over to one Side and Truing Up the Whole Tool.

G. The whole nose of the tool is then bent and set over sidewise, through the use of a flatter, as shown in Fig. 42.

H. The tool should be carefully straightened on the anvil so as to have as nearly as possible a true bearing upon its bottom surface. This bearing should extend all the way from the front to at least half-way back on the tool. A surface plate should be provided close to the blacksmith's anvil for testing the accuracy of this operation. The importance of having this bottom surface true is not ordinarily appreciated. The tool should bear at all points along its bottom surface, at its forward end, directly underneath the cutting edge, in order to avoid chatter or breaking through too much overhang, and directly beneath the clamp to avoid either bending or breaking at this point.

Fire or Heat Cracks in Tools come from Four Principal Causes.

A. The first cause is seams or internal cracks in the bar, caused mainly by imperfections in the ingot or by too rapid or uneven heating in hammering the bar. Blacksmiths are prone to attribute all cracks in their tools to the maker of the tool steel. It is our observation, however, that nine-tenths of the cracks in tools are due to bad treatment in the smith shop rather than to imperfections in the bar.

B. The second cause for cracking is breaking the bar while cold, as referred to above.

C. The third cause is heating the bar unevenly by keeping it in the same position in the fire throughout the time of heating. The portion of the tool next to the fire expands more rapidly than the steel directly above it, and actually tears the colder metal apart.

D. The fourth cause for cracks is too rapid heating in an intense fire. Even if properly turned over and over, the outside portions of a tool (particularly if it be of large body) are heated to a high forging heat before the center of the section has reached its proper temperature. If hammered when in this condition, internal cracks in the tool are likely

Figs. 37, 38 and 39. Figs. 40, 41 and 42.

Successive Stages of Forged and Ground Tools.

to be developed, because the center of the bar, instead of being malleable as the outside is, still remains comparatively cold and brittle, and the steel being unable to flow is torn apart, thus producing internal cracks. Internal cracks are also caused in some cases by hammering the outside of the bar with too light taps of the hammer. The force of the hammer blow should be powerful enough to penetrate to the center of the bar and should, therefore, increase with the size of the steel.

It is from the third and fourth causes (*C* and *D*) that cracks are most frequently developed and, therefore, slow heating and frequent turning of the bar in the fire are to be recommended, particularly during the early stages of heating. If

the heat must be hurried, let it be during the final rise in temperature from the cherry red, say, up to the proper forging heat.

The above remarks refer of course to high-speed tools, not to either tempered tools or the old self-hardening tools which should not be heated beyond a light cherry red in forging.

Relative Work to be Done in the Smith Shop and on the Grinding Machine for Maximum Economy in Making Tools.

It requires much and careful observation, made not in a desultory manner but with a stop-watch, to determine the exact degree of accuracy with which the shape of the nose of the tool should be forged; in other words, to determine how much of the work of shaping the nose of the tool should be done by the smith and how much should be left for the grinder. It is evident that this will depend upon the method and the facilities in the machine shop for rapid and accurate grinding. If the grinding is done by hand, and on a grindstone or on a fine emery wheel, it will take a far longer time and be much more expensive than if done on an automatic grinding machine which is supplied with a corundum wheel, the size of the grit of which is carefully selected, so as to grind with the greatest rapidity while at the same time leaving a sufficiently smooth finish. The better and more rapid the grinding facilities then, the smaller should be the percentage of work done in shaping the tool in the smith shop, and the larger the percentage done by the grinder, and *vice versa*.

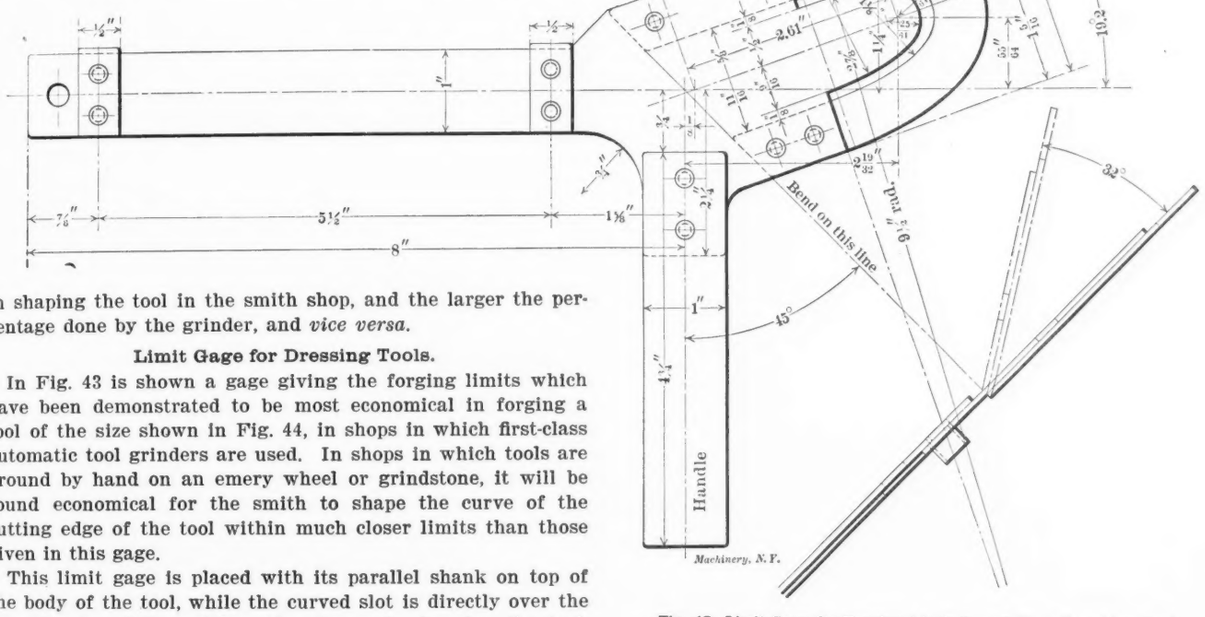


Fig. 43 Limit Gage for Forging 1-inch Round Nose Roughing Tool.

Limit Gage for Dressing Tools.

In Fig. 43 is shown a gage giving the forging limits which have been demonstrated to be most economical in forging a tool of the size shown in Fig. 44, in shops in which first-class automatic tool grinders are used. In shops in which tools are ground by hand on an emery wheel or grindstone, it will be found economical for the smith to shape the curve of the cutting edge of the tool within much closer limits than those given in this gage.

This limit gage is placed with its parallel shank on top of the body of the tool, while the curved slot is directly over the curved nose of the cutting edge, hence in dressing the tool, and in approximating the curve of the cutting edge, all that is required of the smith is that every portion of the outline of the cutting edge of the tool shall come within the limits of the curved slot. On looking down through the slot in the gage, the smith should see the whole outline of the cutting edge of the tool, and, provided the whole line of the cutting edge as left by the smith is in sight through this slot, it is of no consequence whether the curve is irregular and jagged in shape or whether it is left smooth. It will be cheaper for the grinder to grind off the irregularities in the curve than for the smith to take the extra time required for this purpose. Each type of tool used in the machine shop should be carefully studied in this way so as to establish the most economical limits within which the smith is to do his work, and limit gages similar to the one illustrated, should in all cases be carefully made. The writer wishes to emphasize again the desirability of so designing tools and, particularly, of so adjusting the relative amount of work to be done by the grinder and the smith, that all sizes up to 1 x 1½ inch may be dressed in two heats, and still leave as little work as practicable for the grinder.

Importance of Using a Heavy Stream of Water Directly on Nose of Tool in Grinding Tools.

Attention has already been called to the great injury which is constantly being done to the modern high-speed tools by heating the cutting edge too hot on the grindstone. It becomes of the first importance in grinding, whether an automatic tool grinder is used or whether tools are ground by hand, always to throw a heavy stream of water upon the nose directly at the spot where the emery wheel or grindstone is doing its work. The practice of pouring water upon the emery wheel above the tool and allowing the stone to carry the water along with it is to be avoided, as this method provides entirely too small an amount of water to properly cool the tool. We have found by experiment that it requires a stream of water of not less than five gallons per minute, thrown directly upon the cutting edge of the tool, to prevent its being overheated on the grindstone. Even then, the man running the grinder should be under frequent supervision, or the temptation to force the grinding, to hurry his work and thus to overheat the tool, may prove too great. The water should be thrown in a large stream with slow velocity to avoid splashing.

The necessity for not overheating the tool in grinding also modifies the shape for forging our standard tool. The noses of our standard tools, shown in Figs. 41 and 42, have clearance angles of 20 degrees as they come from the smith shop, whereas a clearance angle of 6 degrees is ample for shop use. In other words, the noses of our standard tools lean far forward out of the perpendicular. The object of this is to make the distance beneath the cutting edge, which must be ground off of the flank each time the tool is sharpened as short as possible. In this way a smaller pressure between the tool and the grindstone is called for, the tool is ground in a much shorter time, less heat is generated by the grindstone, and there is less danger of injuring the tool from overheating.

The nose when cut off by the blacksmith has a much more acute lip angle than is actually needed in the machine shop for cutting. This acute angle is given the tool for the same reason as was the extra clearance angle, namely, to diminish the extent of the surface which must be ground from the lip surface of the tool. The diminution in the grinding which results from leaning the nose of the tool forward and cutting a much steeper side slope in the smith shop becomes apparent from a comparison with the view of a tool dressed and ground in the ordinary way, as shown in Figs. 24, 26 and 27 (March issue).

In Figs. 16 to 21 (March issue) it will be noted in each

case that broken lines above and beyond the upper part of the nose of the tool indicate the shape to which the tool is forged, while the solid, heavy lines indicate the shape to which the tool is ground at its first grinding.

Our reason for leaving so much metal in the forged tool to be ground off is that sometimes in giving the tool the high heat, owing to too slow a fire being used, the metal close to the surface of the nose of the tool is somewhat injured, and by grinding off this exposed point of the tool at its first grinding, a tool which runs at once at its highest cutting speed can be obtained.

Tools with Keen Lip Angles much more Expensive to Grind than those with Blunt Lip Angles.

While on the subject of grinding, it should be pointed out that the steeper the side slope of the lip surface, the larger becomes the area of the surface which must be ground, and the smaller the number of times a tool of a given height can be ground before redressing. A steep side slope also renders the cutting edge more likely to be overheated in grinding as it leaves a smaller cross section of metal in the wedge-shaped section close to the cutting edge for carrying away the heat.

If economy of grinding alone then were to be considered, a steep side slope in the tool would be avoided for every reason. A consideration of the above facts will also make it more clear why all machinists who grind their own tools incline toward too little rather than too much side slope.

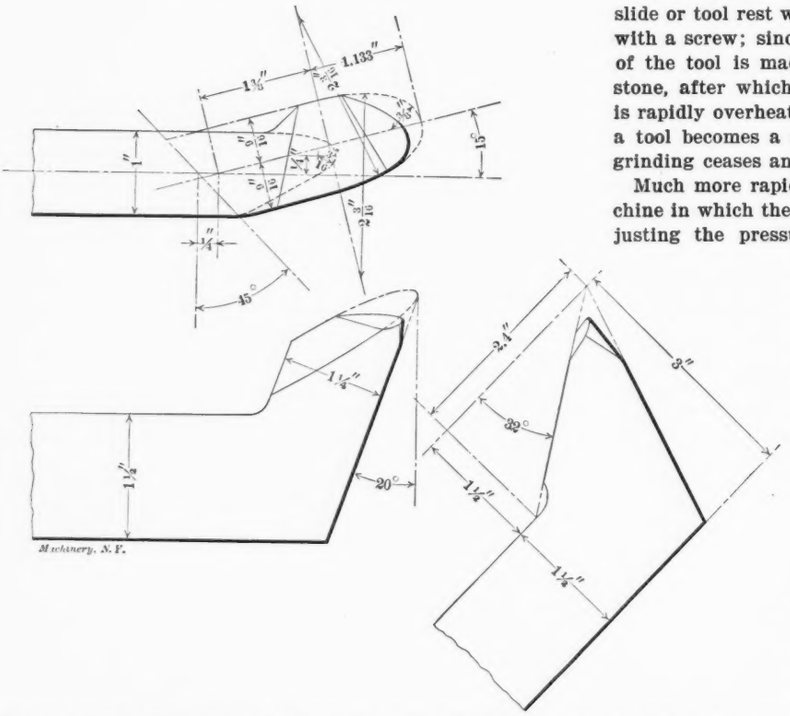


Fig. 44. Detailed Dimensions of 1-inch Round Nose Roughing Tool. Forged Outline shown by Dotted Lines and Ground Form by Full Lines. Clearance, 6 degrees; Back slope, 8 degrees, and Side Slope 14 degrees.

Flat Surfaces Tend to Heat the Tools in Grinding.

Flat surfaces coming into contact with the emery wheel also tend very greatly to heat the tool, chiefly because the surface which is being worked upon is soon ground so as to fit so exactly and closely against the outside surface of the grindstone that no water can find its way between the stone and the tool and thus cool the latter. It is for the purpose of giving the water free access to the face of the tool being ground that in grinding tools by hand the best grinders invariably keep the tool more or less wobbling about upon the face of the grindstone while the greater part of the metal is being roughed off. For the same reason they hold the tool stationary against the stone only during the last stage of the grinding when finishing the lip surface to the exact angle required. In selecting an automatic grinder, no machine should be purchased which does not permit free access of the water to the flat surface of the tool during the operation of grinding.

It is for a similar reason also that tools with a curved cutting edge are to be preferred from the standpoint of grinding to those with a straight line on the cutting edge. The straight line always implies a flat clearance surface beneath the cutting edge for grinding, and a flat surface is far more difficult to grind without heating than a curved surface.

The Selection of the Emery Wheel.

The selection of the proper emery wheel for tool grinding is also a matter of great importance. The hardest grit obtainable should be used, and for grinding ordinary shop tools, so far as we know, corundum is the best. Rapid grinding is promoted by the use of a coarse grit in the wheel. On the other hand, too coarse grit leaves an irregular outline at the cutting edge of the tool. After experimenting with emery wheels varying greatly in their coarseness, we have adopted as our standard an emery wheel having a mixture of grits known as size No. 24 and size No. 30. A corundum wheel made of these two sizes of grit grinds fast and leaves a sufficiently smooth finish on the tool.

Desirable Features in an Automatic Tool Grinding Machine.

Tools should never be ground by fastening them solidly in a slide or tool rest which is fed directly against the emery wheel with a screw; since soon after the grinding starts, the surface of the tool is made to fit exactly against the surface of the stone, after which grinding is exceedingly slow and the tool is rapidly overheated. It may almost be said that the moment a tool becomes a close fit against the side of the grindstone, grinding ceases and heating begins.

Much more rapid grinding can be done upon a grinding machine in which there is provided a means for automatically adjusting the pressure of the tool against the emery wheel. Each sized tool should have adapted to it a pressure which is automatic and which is just sufficient to grind rapidly without danger of overheating. An automatic machine of this type will do about twice the work of a machine in which the pressure between the tool and the emery wheel is regulated according to the judgment of the grinder.

Desirability of a Large Supply of Tools, a Complete Tool Room, and an Automatic Grinding Machine, even in a Small Shop.

We have pointed out that the greatest gain from a study of the art of cutting metals can be attained only through reorganizing the system of management of the shop in such a way that it is possible to assign daily tasks to the workmen, and that in preparing for this a thorough system must be established for delivering to each workman an ample supply of tools ground to standard shapes ready for use. This involves a tool room with ample storage space for a large number of extra tools. For economy, even in a small shop, the tools should be ground in lots or batches, *i. e.*, there should be such an ample supply of tools in the shop that dull tools of a given size and shape can be allowed to accumulate until a lot, say, ten to twenty or more, is ready for the grinder. With this system it is economical for the small shop as well as the large one to use an automatic tool grinder.

In our experience in reorganizing the management of machine shops we almost invariably have difficulty in persuading the owners to maintain the large supply of tools which is needed to get the full benefit from the task system. It seems desirable, therefore, to lay particular stress upon all of the elements connected with the tool supply—of which accurate and rapid grinding without injuring the tool is the most important. There is little if any economy in the use of an automatic tool grinding machine unless standard shapes for all tools have been adopted, and unless a large supply of tools is kept in a well-equipped tool room, from which they are issued to the men, no workman being allowed to grind his own tools.

BEVEL GEAR DIAGRAMS.

GEO. S. HOELL.

In preparing shop drawings of bevel gears with planed teeth, a comparatively large amount of figuring has to be done, modern practice demanding greater accuracy than can be obtained even by carefully laying out the gear full size. Those drawing rooms in which gear design is of daily occurrence, are usually equipped with extensive tables, as well for pitch diameters as for pitch angles of bevel gears. As far as my experience goes, these two data are most conveniently recorded in a tabular form, as is the usual practice. But a few other data are necessary for dimensioning the gear, such as the angle of increment, the outside diameter, and the projection of the extreme edge of the teeth beyond the pitch circle.

Brown & Sharpe, in one of their books on gear dimensions, have a table giving the Angle of Face, this being the complement of the face angle indicated by the cut in the supplement. The trouble with tables is that they are voluminous and liable to errors, and, in this particular case, that some of the angles repeat themselves several times. Other books give very extensive tables for the outside diameters, all calculated for 1 diametral pitch, the outside diameter in other cases to be found by dividing the tabular dimension by the diametrical pitch of the gear under consideration, the latter operation being very cumbersome when an even circular pitch is being used. The dimension b in the cut is sometimes tabulated in a similar way. The accompanying diagrams (see Supplement) contain, in a very concentrated and convenient shape, all the data just mentioned.

The best way of explaining the diagrams is to take an example, such for instance, as the following: Find the outside diameter, face angle, and backing b of a bevel gear with 40 teeth, whose pitch angle is 56° 59′, 2 diametral pitch, 20 inches pitch diameter. Referring to the curve sheet for values of a, follow a line close to the 57-degree pitch angle line, until it intersects the curve for $2P$. Follow this point horizontally to the left, and we find that a equals 0.272 inch. The outside diameter will be the sum of the pitch diameter, 20, and $2a$, or 20.54 inches. Dimension b may be found from the same sheet in the same manner, excepting that the pitch angles must be read in the opposite direction. Thus we have to read off 56° 59′, where 33° 1′ is indicated, and, in the same way as above described, we find that b equals 0.417 inch, the last figure being estimated. Following the corresponding line for 56° 59′ on the other diagram, to the intersecting point with the line indicated by 40 (teeth), and radiating from zero, we find by transferring this point over to the scale for the angles of increment, that the latter in this case equals 2° 23′, the units of the minutes being estimated. This angle added to the pitch angle of 56° 59′, gives a face angle of 59° 22′.

* * *

BEVEL GEAR FORMULAS.

HERMAN ISLER.

Much has been written about miter and bevel gears, and a number of methods have been proposed by different designers for the solution of the problems involved. From these different articles I have compiled a systematic set of formulas (see Supplement) both for diametral and circular pitches. The formulas are very simple; it is necessary, however, that the draftsman be able to read the tables of trigonometrical functions. The following examples have first been solved graphically, by laying them out full size, and then have afterwards been compared with the figures obtained by the formulas given in these tables.

Example 1. Miter Gears.

Given: Pitch diameter $D = 5$ inches, diam. pitch $P = 6$, face $Y = 1\frac{1}{4}$ inch.

Number of teeth $N = D \times P = 5 \times 6 = 30$

$$\text{Outside diameter } O = D + \frac{1.4142}{P} = 5 + \frac{1.4142}{6} = 5.236 \text{ inches.}$$

$$\text{Tan } s = \frac{1.4142}{N} = \frac{1.4142}{30} = 0.04714,\ s = 2° 42'$$

$$\text{Tan } f = \frac{1.6362}{N} = \frac{1.6362}{30} = 0.05454,\ f = 3° 7'$$

Turning angle $a = 45° + s = 45° + 2° 42' = 47° 42'$

Cutting angle $\beta = 45° - f = 45° - 3° 7' = 41° 53'$

$$\text{Distance } M = \frac{O}{2} - \frac{1.4142}{P} = 2.618 - 0.236 = 2.382 \text{ ins.}$$

$$\text{Distance } H = Y \times \cos a = 1\tfrac{1}{4} \times 0.67301 = 0.841 \text{ inch.}$$

If the gears are cut, use the following formula to find number of teeth, for which to select cutter: $N \times 1.4142 = 30 \times 1.4142 = 42$ teeth.

Example 2. Miter Gears.

Given: No. teeth $N = 25$, circular pitch $C = \frac{1}{2}$ inch, face $Y = \frac{3}{8}$ inch.

Pitch diameter $D = 0.3183\,C\,N = 0.3183 \times 0.5 \times 25 = 3.979$ ins.

Outside diameter $O = D + 0.45\,C = 3.979 + (0.45 \times 0.5) = 3.979 + 0.225 = 4.204$ inches

$$\text{Tan } s = \frac{1.4142}{N} = \frac{1.4142}{25} = 0.05657,\ s = 3° 14'$$

$$\text{Tan } f = \frac{1.6362}{N} = \frac{1.6362}{25} = 0.06545,\ f = 3° 45'$$

Turning angle $a = 45° + s = 45° + 3° 14' = 48° 14'$

Cutting angle $\beta = 45° - f = 45° - 3° 45' = 41° 15'$

$$\text{Distance } M = \frac{O}{2} - 0.45\,C = 2.102 - 0.225 = 1.877 \text{ inch}$$

$$\text{Distance } H = Y \times \cos a = \tfrac{3}{8} \times 0.66610 = 0.583 \text{ inch}$$

Number of teeth for which to select cutter $= N \times 1.4142 = 25 \times 1.4142 = 35$ teeth.

Example 3. Bevel Gears (Shaft Angle 90 Deg.)

Given: No. teeth of pinion $N = 27$, No. teeth of gear $N_1 = 45$, dia. pitch $P = 8$, face $Y = \frac{3}{4}$ inch.

PINION.

$$\text{Pitch diameter } D = \frac{N}{P} = \frac{27}{8} = 3.375 \text{ inches}$$

$$\text{Tan } \phi = \frac{N}{N_1} = \frac{27}{45} = 0.600,\ \phi = 30° 58'$$

$$\text{Outside diameter } O = D + \frac{2 \cos \phi}{P} = 3.375 + \frac{2 \times 0.85747}{8}$$

$$= 3.375 + 0.214 = 3.589 \text{ inches}$$

$$\text{Tan } s = \frac{2 \sin \phi}{N} = \frac{1.02908}{27} = 0.03811,\ s = 2° 11'$$

$$\text{Tan } f = \frac{2.314 \sin \phi}{N} = \frac{1.19065}{27} = 0.04410,\ f = 2° 32'$$

Turning angle $a = \phi + s = 30° 58' + 2° 11' = 33° 9'$

Cutting angle $\beta = \phi - f = 30° 58' - 2° 32' = 28° 26'$

$$\text{Distance } M = \frac{O_1}{2} - \frac{2 \sin \phi}{P} = 2.877 - 0.129 = 2.748 \text{ ins.}$$

(The value of O_1 is obtained from the calculations for the gear, which follow.)

$$\text{Distance } H = Y \times \cos a = 0.75 \times 0.83724 = 0.628 \text{ inch}$$

Number of teeth for which to select cutter:

$$\frac{N}{\cos \phi} = \frac{27}{0.85747} = 31 \text{ teeth.}$$

GEAR.

$$D_1 = \frac{N_1}{P} = \frac{45}{8} = 5.625 \text{ inches}$$

$$\phi_1 = 90 - \phi = 90° - 30° 58' = 59° 2'$$

$$O_1 = D_1 + \frac{2 \sin \phi}{P} = 5.625 + \frac{1.02908}{8}$$

$$= 5.625 + 0.129 = 5.754 \text{ inches}$$

$$a_1 = \phi_1 + s = 59° 2' + 2° 11' = 61° 13'$$

$$\beta_1 = \phi_1 - f = 59° 2' - 2° 32' = 56° 30'$$

$$M_1 = \frac{O}{2} - \frac{2 \cos \phi}{P} = 1.795 - 0.214 = 1.581 \text{ inch}$$

$$H_1 = Y \times \cos a_1 = 0.75 \times 0.48150 = 0.361 \text{ inch}$$

Number of teeth for which to select cutter:

$$\frac{N_1}{\sin\phi} = \frac{45}{0.51454} = 87 \text{ teeth.}$$

Example 4. Bevel Gears (Shaft Angle less than 90 Deg.)

Given: No. teeth of pinion $N = 15$, No. teeth of gear $N_1 = 30$, shaft angle $x = 60°$, dia. pitch $P = 6$, face $Y = 1\frac{1}{4}$ inch

PINION.

Pitch diameter $D = \frac{N}{P} = \frac{15}{6} = 2.5$ inches

$$\text{Tan}\,\phi = \frac{\sin x}{\frac{N_1}{N} + \cos x} = \frac{\sin 60°}{\frac{30}{15} + \cos 60°}$$

$$= \frac{0.86603}{2 + 0.5} = 0.34641$$

$$\phi = 19° 6'$$

$$\text{Outside diameter } O = D + \frac{2\cos\phi}{P} = 2.5 + \frac{2 \times 0.94495}{6}$$

$$= 2.815 \text{ inches}$$

$$\text{Tan}\,s = \frac{2\sin\phi}{N} = \frac{2 \times 0.32722}{15} = 0.04363,\ s = 2° 30'$$

$$\text{Tan}\,f = \frac{2.314\sin\phi}{N} = \frac{2.314 \times 0.32722}{15} = 0.05048,\ f = 2° 53'$$

Turning angle $a = \phi + s = 19° 6' + 2° 30' = 21° 36'$
Cutting angle $\beta = \phi - f = 19° 6' - 2° 53' = 16° 13'$

$$\text{Distance } M = \frac{O}{2} \times \cot a = 1.408 \times 2.52571$$

$$= 3.556 \text{ inches.}$$

Distance $H = Y \times \cos a = 1.25 \times 0.92978 = 1.162$ inch.

Number of teeth for which to select cutter:

$$\frac{N}{\cos\phi} = \frac{15}{0.94495} = 16 \text{ teeth.}$$

GEAR.

$$D_1 = \frac{N_1}{P} = \frac{30}{6} = 5 \text{ inches}$$

$$\phi_1 = x - \phi = 60° - 19° 6' = 40° 54'$$

$$O_1 = D_1 + \frac{2\cos\phi_1}{P} = 5 + \frac{2 \times 0.75585}{6} = 5.252 \text{ inches}$$

$$a_1 = \phi_1 + s = 40° 54' + 2° 30' = 43° 24'$$
$$\beta_1 = \phi_1 - f = 40° 54' - 2° 53' = 38° 1'$$

$$M_1 = \frac{O_1}{2} \times \cot a_1 = 2.626 \times 1.05747 = 2.777 \text{ inches}$$

$$H_1 = Y \times \cos a_1 = 1.25 \times 0.72657 = 0.908 \text{ inch}$$

Number of teeth for which to select cutter:

$$\frac{N_1}{\cos\phi_1} = \frac{30}{0.75585} = 40 \text{ teeth.}$$

Example 5. Bevel Gears (Shaft Angle more than 90 Deg.)

Given: No. teeth of pinion $N = 18$, No. teeth of gear $N_1 = 30$, shaft angle $x = 105°$, dia. pitch $P = 6$, face $Y = \frac{3}{4}$ inch,

PINION.

Pitch diameter $D = \frac{N}{P} = \frac{18}{6} = 3$ inches

$$\text{Tan}\,\phi = \frac{\cos(x - 90°)}{\frac{N_1}{N} - \sin(x - 90°)} = \frac{\cos 15°}{\frac{30}{18} - \sin 15°}$$

$$= \frac{0.96593}{1.66666 - 0.25882} = 0.68611,$$

$$\phi = 34° 27'$$

$$\text{Outside diameter } O = D + \frac{2\cos\phi}{P} = 3 + \frac{2 \times 0.82462}{6}$$

$$= 3.275 \text{ inches}$$

$$\text{Tan}\,s = \frac{2\sin\phi}{N} = \frac{2 \times 0.56569}{18} = 0.06285,\ s = 3° 36'$$

$$\text{Tan}\,f = \frac{2.314\sin\phi}{N} = \frac{2.314 \times 0.56569}{18} = 0.07272,$$

$$f = 4° 10$$

Turning angle $a = \phi + s = 34° 27' + 3° 36' = 38° 3'$
Cutting angle $\beta = \phi - f = 34° 27' - 4° 10' = 30° 17'$

$$\text{Distance } M = \frac{O}{2} \times \cot a = 1.637 \times 1.27764$$

$$= 2.091 \text{ inches}$$

Distance $H = Y \times \cos a = 0.75 \times 0.78747 = 0.5906$ inch

Number of teeth for which to select cutter:

$$\frac{N}{\cos\phi} = \frac{18}{0.82462} = 22 \text{ teeth.}$$

GEAR.

$$D_1 = \frac{N_1}{P} = \frac{30}{6} = 5 \text{ inches}$$

$$\phi_1 = x - \phi = 105° - 34° 27' = 70° 33'$$

$$O_1 = D_1 + \frac{2\cos\phi_1}{P} = 5 + \frac{2 \times 0.33298}{6} = 5.111 \text{ inches}$$

$$a_1 = \phi_1 + s = 70° 33' + 3° 36' = 74° 9'$$
$$\beta_1 = \phi_1 - f = 70° 33' - 4° 10' = 66° 23'$$

$$M_1 = \frac{O_1}{2} \times \cot a_1 = 2.555 \times 0.28891 = 0.725 \text{ inch}$$

$$H_1 = Y \times \cos a_1 = 0.75 \times 0.27312 = 0.205 \text{ inch}$$

Number of teeth for which to select cutter:

$$\frac{N_1}{\cos\phi_1} = \frac{30}{0.33298} = 90 \text{ teeth.}$$

* * *

A GAS ENGINE WRITE-UP.

We recently received a description of a new gas engine having a most extraordinary introduction, as follows:

"A Miracle of Simplicity, Efficiency, and Economy! The Evolution of Power, from the primitive steam engine, crude and imperfect, but containing the principle which made possible the monsters of iron and steel, which have revolutionized the world, to the new mechanical marvel, the gas or air expansion engine, includes the history of all modern progress and all modern civilization. With the steam engine, wonders were done—with the gas engine miracles have happened. With its aid, navigation of the air is an accomplished fact—automobiles skim the earth at a speed deemed, a few years ago, unattainable—submarine boats dive into the depths of the seas like ducks—and Power, which has multiplied a million-fold the productive capacity of human hands, has been placed within reach of even the farmer, to aid the bounty of Nature."

And then down, bump, we come from the empyrean to a description of the "perfect" gas engine. This matter, sent with electrotype cuts to all the trade journals, is assumed by the misguided press agent to be the kind of stuff that sells goods. But it is not so, for the methods of Tody Hamilton, the veteran Barnum & Bailey advertising manager, do not apply well to descriptions of machinery. A plain, matter-of-fact article, pointing out the new features of design and the advantages claimed, is generally best. Over-statement weakens the strength of any claim, and when couched in such extravagant language as given above, it becomes ridiculous.

* * *

A curious gas engine break-down was described in a recent issue of the *Mechanical Engineer*. The connecting-rod broke on account of insufficient lubrication for the cross-head pin in the trunk piston. The engine was running satisfactorily when the rod broke without warning about a quarter of the length of the rod from the wrist-pin. Immediate examination discovered that the two broken ends of the connecting-rod were "blue hot," and when a rope was tied around the broken shank to pull the piston out of the cylinder, the rod was found hot enough to burn the rope. The fracture was due to the rapid bending of the rod back and forth, the wrist-pin bearing having seized on the pin. The rapid bending of the rod had raised its temperature in the same manner as a wire heats up when bent back and forth with the fingers.

TO FIND THE RADIUS, HAVING GIVEN THE ARC AND THE MIDDLE ORDINATE.

Referring to the problem of finding the radius of an arc having given only the length of the arc and its middle ordinate, of which we have had some discussion recently in the letters department and in "How and Why," Mr. J. J. Clark, manager of the text-book department of the International Correspondence Schools, Scranton, Pa., writes us that a member of their faculty has worked out the following formulas which give close results in the extreme cases of the semi-circle and an arc of 120 degrees, and still closer approximations when the arc is short, as will be seen in the last example:

Let d = the diameter,
l = length of the arc,
h = middle ordinate (which of course is the versed sine of half the arc).

$$n = \frac{h}{3\,l}.$$

Then the following formula can be applied, first determining the value of n for convenience in working out the equations:

$$d = l\left(\frac{17 - 60\,n^2 + 8\sqrt{1-60\,n^2}}{300\,n}\right)$$

If n is small, the formula may be shortened to

$$d = l\left(\frac{1}{12\,n} - n\right), \text{ or, more accurately,}$$

$$d = \left[\left(\frac{l}{2\,h}\right)^2 - \frac{1}{3} - \left(\frac{2\,h}{3\,l}\right)^2\right]h$$

For a semi-circle, the first formula gives $d = 2.0609$
the second formula gives $d = 2.1341$
the third formula gives $d = 2.08905$
For an arc 120 degrees, the first formula gives $d = 2.01074$
the second formula gives $d = 2.03622$
the third formula gives $d = 2.01861$

d should, of course, equal 2 in all cases.

The third formula perhaps is the most convenient to use and is quite accurate enough for most practical purposes. Below is given an example in which the length of the arc is short:

$$l = 0.5236 \qquad h = 0.03407$$

$$n = \frac{0.03407}{1.5708} = 0.0216$$

$$\text{Then } d = \left[\left(\frac{0.5236}{0.06814}\right)^2 - \frac{1}{3} - \left(\frac{0.06814}{1.5708}\right)^2\right] 0.03407$$

$$= 2.00165$$

The actual diameter is 2, the same as before.

* * *

THE SHOP OPERATION SHEETS.

With this issue a series of shop operation sheets is begun which is intended to present, from month to month, methods of procedure for a great variety of machine shop operations, in as clear and concise a manner as possible. These will include examples of lathe, planer, milling machine, drill press and other standard machine work, and bench and erecting work as well. In general, each operation will be illustrated, and the effort will be made to show as much as possible in the cuts, reducing the description to steps arranged in logical order and worded in the shortest manner. Some operations may require more space than can be given in one issue, and on the other hand some may require only one section of a sheet. Consequently, it will not be attempted to invariably make each sheet complete in itself, or to have each sheet pertain to one subject alone. In a year thirty-six shop operations will be given to each subscriber, in convenient shape for filing or binding, and in the course of a few years we hope to gather together in this shape the best exposition of machine shop practice, simply presented, that ever has been published. Suitable contributions for these sheets will be accepted from our readers. For further information write to the Editor.

MULTIPLE SPINDLE ATTACHMENT FOR UPRIGHT DRILLS.

OSCAR E. PERRIGO.

In many classes of manufacturing work, and particularly in small or moderate sized jig work, a multiple spindle drill is not only very desirable, but in some cases a positive necessity when we come to consider the question of the quantity of the output. While there are a number of very ingenious and well designed drill holders by means of which drills of different diameters may very quickly be substituted for each other, the operations, however rapid, must consume some time. If we were to make an accurate time study in detail, including every motion from the time the operator picks up his piece of work until he lays it down after having completed the designated operation upon it, we should frequently be surprised at the large percentage of time spent in handling the tools, the jig, or the fixture and the work, in comparison with the time employed in the actual operation of the tool. Considerable time must be employed in these time studies if we are to fully realize the importance of reducing the *handling* time, for therein lies the broader and easier field for improvement in reducing the operating time, and hence the cost of machining the product.

It is much more often the case that good, single spindle drills are at hand than that we have those provided with multiple spindles. The present properous conditions of all manufacturing operations have created such demands for all classes of machine tools that it is well nigh impossible to obtain them at short notice or when they are most wanted. It was under these conditions, and from considerations of this character, that the multiple spindle attachment about to be described was designed. The upright drill which was available for this purpose had a circular table about 30 inches in diameter, and a 2½-inch spindle.

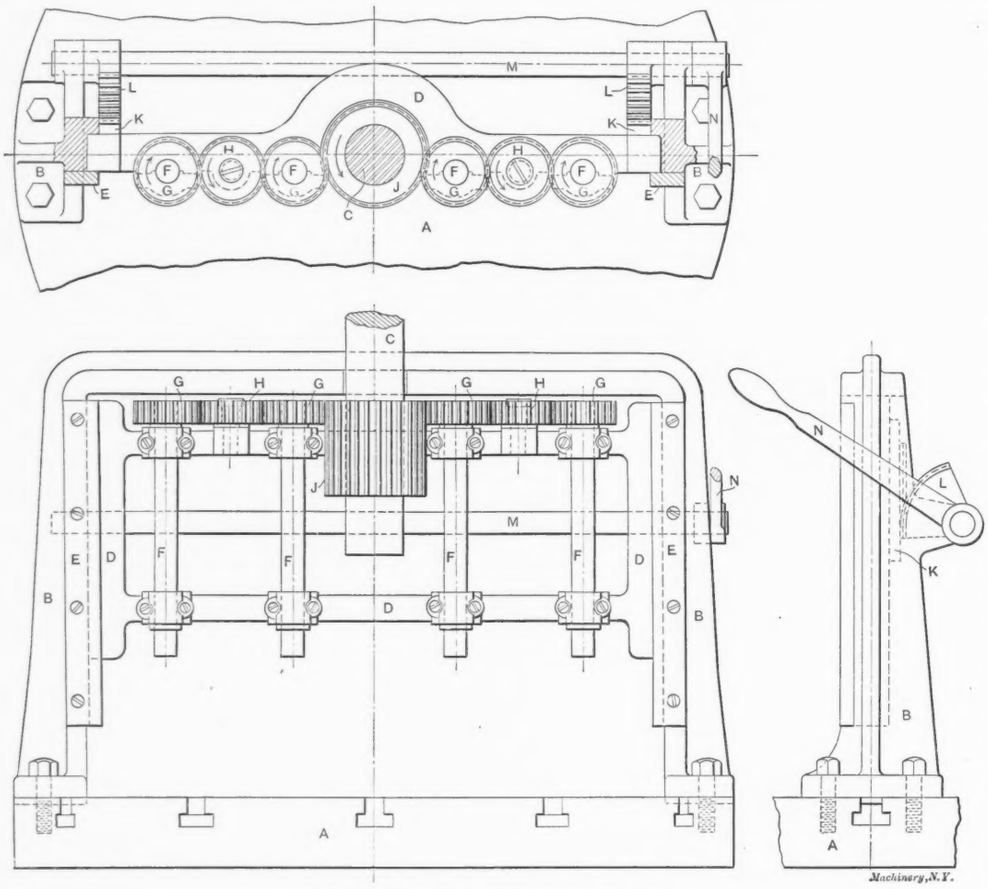
Referring to the cut, the front elevation of the attachment shows the method of its fastening to the table. The end elevation shows the method of feeding the drills by a single lever, in connection with a rack and segment. A plan and partial horizontal section is shown, where the top member of the main frame has been omitted in order to more clearly show the driving mechanism. The general construction of the device is as follows: Upon the drill table *A* is bolted the main frame *B*, secured by bolts as clearly shown in the cut, The main spindle *C* of the drill passes down in front of the center of this fixed frame, its top member being cut away for that purpose as shown in top view. Sliding vertically in the frame *B* is fitted the spindle frame *D*, held in place by the gibs *E E*, and having journaled in it the drill spindles *F F F F*, upon whose upper ends are fixed the spur pinions *G G G G*, by which they are driven. The pair of spindles on each side of the drill spindle *C* have their driving pinions connected by idle pinions *H H*, and the power communicated to the entire train by the elongated gear *J*, fixed to the drill spindle *C*. The idle pinions *H H* run upon studs screwed into the top member of the sliding frame *D*. The gear *J* is of sufficient width of face to transmit the power to the auxiliary drill spindles *F F F F* at any point within the limit of their vertical movement.

The movement of the sliding frame *D* is accomplished by means of the racks *K K*, attached to its rear side, and engaged by the toothed segments *L L*, fixed to the rock shaft *M*, which is journaled in rearwardly projecting brackets on the main frame *B*, and controlled by the hand lever *N*, by which the drills are fed downward. To balance the weight of the sliding frame *D*, the lever *N* may be counterbalanced by a weight formed upon, or attached to, a rear extension of it, or better by spiral springs attached by their lower ends to the sides of the sliding frame *D*, and their upper ends to the top member of the main frame *B*. When in operation the main spindle *C* of the drill is locked in reference to its vertical position so as to properly locate the driving gear *J*. If the driving belt of the drill be running open it is crossed, so as to give a proper direction to the revolution of the spindles as shown by the arrows. For very light work, and in cases where the noise of the rapidly running gears is objectionable, flat or even round belts may be used, and the expense of the

gears partially avoided. In this case but two belts need be used, an idler being properly placed to give sufficient belt contact to drive the drills.

In case it is necessary to locate the several drill spindles in various positions in relation to each other, so as to drill several holes simultaneously, the idle pinions *H H* may be carried by movable brackets similar to the change gears of an engine lathe. The drill spindles may be journaled in boxes sliding in a slot in the movable frame, or sliding upon the horizontal bars of the frame. It might, for the same reason, be necessary to interpose between the driving gear *J* and the pinions on the drill spindles adjustable idle gears or pinions.

The drill spindles need not necessarily be located in a straight line, but may be so located as to fit the holes in any special piece of work. They may be equally spaced around a circle if much work is to be done of this form. The spindles may be located by radial slots in an upper and lower plate, properly connected so as to constitute a sliding frame, and



Multiple Spindle Attachment for Upright Drills.

running in three or four vertical guides. By this means holes placed in circles of varying diameters may be drilled. In such a device the drill spindles might be driven by one or the other of the methods described above. The practical utility of the device is readily seen, as the ordinary single spindle drill may be easily and economically converted into a useful multiple spindle drill with any desired number of spindles, and located in any desired arrangement.

* * *

The Union Iron Works, San Francisco, Cal., has undertaken what is said to be the heaviest task in the way of repairing a merchant vessel ever undertaken in the United States. It is the removing of the entire bottom of the Pacific mail steamship *Manchuria* which was wrecked on the rocks of the Hawaiian Islands several months ago. The entire bottom will have to be rebuilt. Over 300 shell plates and 90 per cent of the floor plates will be replaced. The job will employ 600 men and will require 1,560 12 x 12-inch timbers for shores. Notwithstanding the greatness of the job it is expected that it will be completed in four months time.

SUGGESTED REFINEMENT IN THE HOBBING OF WORM-WHEELS.

R. E. FLANDERS.

At the right of Fig. 1 is a sectional view showing a hob in the act of putting the last finishing touches on a worm-wheel. The hob is supposed to be a new one and is shown in the condition it is when first received from the makers. At the left of Fig. 1 is shown the same hob putting the finishing touches on a worm-wheel similar to that in the first case. The hob in this case is represented as having been in use for a considerable time, and having been ground down to the last extremity, ready to be discarded for a new one. A study of this cut will show that if the hob is made in the first place to properly match the worm which is to drive the wheel, it will not, when worn, cut exactly the proper form of tooth in the blank to mesh with that worm. The teeth are cut to the same depth in each case, this being necessary in order to make a proper fit with the worm, which is the same in each case and it set at the same center distance. The grinding away of the worn hob has reduced its diameter by an amount indicated by dimension *b*. Its center is therefore at *P* on the line *A B*, which is offset by a distance represented by dimension *a* from the line *C D* in which the center *O* of the new hob is located. This reduction in diameter as the hob is ground away from time to time, so evidently follows from the construction of the relieved hob, that it scarcely needs to be explained.

It is said of relieved hobs that they can be ground without changing their shape. This is true so far as the outline of the cutting edge is concerned, but it will be evident on examining the conditions shown in the left hand of Fig. 1, that whatever the outline of the cutting edges, a new hob of radius *R* will not cut exactly the same shape teeth in the blank as the worn hob with radius *r*. The elements of the tooth surface it generates are struck from a center *P*, removed by dimension *a* from center *O'* which is the location of the axis of the worm with which it meshes.

It is possible, and perhaps practicable, to overcome this slight error; that is, to so design and use the hob that it will cut as correct teeth when worn as when new. In Fig. 2, dotted line *A A* represents the outlines of a new hob in the act of finishing the worm-wheel shown. Were a hob, ground as shown at the left of Fig. 1, to be substituted on the arbor for this new hob, without altering the adjustment of the machine except to move the hob endwise and bring it in contact with the teeth of the wheel on one side, this hob would be represented in Fig. 2 by the full line *B B*. It is evident that the left hand cutting edges of this hob coincide (to the depth they extend into the wheel) with those of the new hob represented by outline *A A*. They will, therefore, so far as they extend, cut identically similar and correct tooth curves with the new hob.

Teeth cut with this worn hob would, however, evidently

have two faults. The space would be too narrow at the pitch line by a distance measured by dimension *m*, and they would not be cut deep enough in the blank by a distance measured by dimension *n*. Our problem is to so alter the design and application of the hob, that, even when it is worn, we can cut the teeth deep enough and the space wide enough.

Fig. 3 shows these conditions fulfilled. Dotted line *C C* shows the outline of the proposed hob when new. The only difference between the proposed hob and the regular one, whose outlines are shown by the dotted line *A A* in Fig. 2, is that the teeth have been lengthened by an amount equal to dimension *o*. The hob is fed in as was the case with the new hob in Fig. 2 until the distance between its center line and that of the blank is the same as that between the center line of the worm and the wheel in the finished machine. The increase in radius, then, by an amount *o*, makes the hob cut a clearance deeper than is necessary by that amount. In a spur gear this would doubtless be a bad thing, since it would make the tooth slenderer and therefore weaker. A worm gear, however, if designed to be sufficiently durable for continuous use, is almost certain to be several times stronger than necessary, so that the slight weakening involved in the change is not of great importance. When the hob is worn to the shape shown by the full outline *D D*, the hob is evidently of the same diameter as the new one in Fig. 2, represented by dotted outline *A A*. Our tooth space, however, as before explained, will be too narrow by the amount *m* in Fig. 2 or *p* in Fig. 3. To widen it out sufficiently, it is therefore necessary for us, after the hob has been fed in to the proper depth, to still continue the cutting action, feeding the hob endwise, however, until it has been displaced to the position indicated by outlines *D' D'*. The resulting tooth is evidently identical with that given by the new hob *A A* in Fig. 2.

It will be understood that when the hob in Fig. 3 is new, it will not have to be shifted endwise at all, since it will cut a tooth space of the proper width as soon as fed to depth. It will, however, cut a space deeper than necessary by an amount *o*. The worn hob, on the other hand, has to be shifted longitudinally by an amount *p* and cuts to exactly the required

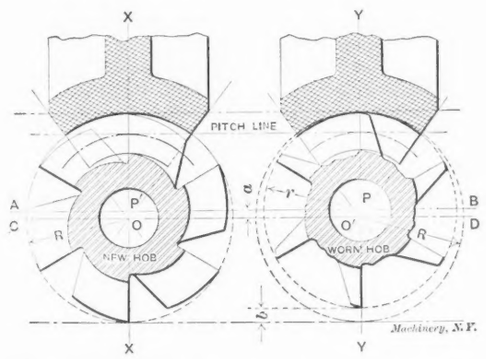


Fig. 1. The Difference in Shape of Teeth Cut by New and Old Hobs.

depth. These represent the two extreme conditions. When the hob is half worn, the excess clearance will be equal to half of *o*, and the longitudinal displacement necessary will be equal to half of *p*.

While the change in the design of the hob could be made easily enough, there is doubtless some difficulty in making the required change in the hobbing of the blank. Taking it for granted that the hob has been made to suit the worm which is to be used, and that it, therefore, has the same pitch diameter and thickness of tooth at the pitch line, the method of procedure will invariably require that the hob be fed in to the worm-wheel blank until the distance from the center of the hob to that of the wheel, is the same as the distance from the center of the worm to that of the wheel in the finished machine. This will be true whether the hob is new or worn, and whatever may be the kind of machine on which the hobbing is being done.

The method by which the hob is displaced longitudinally will depend on the machine used for the operation. There will be no possible way of doing it if the wheel is being finished while running loosely on centers, as is common practice when the blank has first been gashed. It is required that the hob and blank be positively geared together. If a positively driven hobbing attachment in the milling machine is being used, the matter is simple. If the hob is being driven by the spindle of the machine, throw in the cross feed in either direction until the required longitudinal displacement of the wheel with relation to the hob has taken place. The question as to when this has taken place may be decided either by measuring the thickness of the tooth, as in cutting spur gears, or by trying the wheel from time to time with its worm, the two parts being mounted in place in the machine they are to go in, or held the proper distance apart by other means.

For regular hobbing machines, as at present made, the matter is more difficult. The required longitudinal displacement of the hob may be obtained, in effect, by a rotary displacement of the hob which may be accomplished by slipping (a

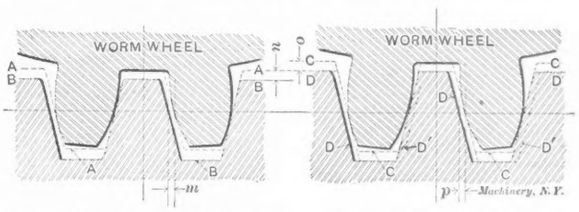


Fig. 2. Cutting Action of Ordinary Hob at Fixed Center Distance, when new and whe worn.

Fig. 3. Cutting Action of Proposed Hob, when new and when old.

tooth at a time), the teeth of the change gears connecting the hob and the blank. If a hobbing machine were to be built especially for use in the way suggested in this article, differential gearing could be introduced in the train between the hob and the wheel, to which a power feed could be given to effect the rotary displacement when the hob had been fed to depth; or a power feed might be applied to feed the spindle and its attached hob endwise to effect the same result.

The writer is not certain that the error which exists in the use of relieved hobs is of enough importance to warrant taking any trouble to remedy it. It is always well, however, to know and understand such errors as may exist in any process of this sort, no matter if they are of no great practical importance. While some designers and shop men have doubtless recognized the existence of this particular error, still probably most of them take it for granted that the process is absolutely accurate, since they are so often reminded that the relieved hob can be "ground without change of shape."

* * *

AN EXAMPLE OF THE RESISTING POWER OF SOFT MATERIALS.

In dealing with automatic machinery, experimenters have often found most surprising results in the use of soft materials, where harder ones have failed to stand the racket. In a recent article in a contemporary, for instance, was described the difficulty experienced by a manufacturer with the feed rolls for a wire drawing machine. Although made of the best steel obtainable, hardened and toughened to the highest degree, these rolls still rapidly wore away under the friction of the stock they were feeding. The problem of making durable feed rolls was finally solved by making them of *annealed* steel. When this principle was discovered and applied, no further difficulty was met with.

Another case illustrating the resistance of soft materials to wear came to our notice a few days ago. It was an incident of an entirely different character, but illustrates the same principle. A split box carrying the feed shaft on a certain woodworking machine was too tight, so that it caused the bearing to heat. The operator inserted a slip of paper under the cap on one side. This slip of paper was so long that it projected beyond the shaft, within the range of a projecting set screw in a collar on the shaft, which struck it at every revolution—that is to say, about 100 or 120 times per minute. The set screw struck this paper for practically a full working day, every working day for seven years, without destroying the elasticity of the paper or entirely wearing it away. The screw, meanwhile, had been polished bright and perceptibly worn by the friction of the paper.

MACHINERY'S NEW OFFICES.

The above illustration shows the twelve-story building in which MACHINERY's offices are now located, at 49-55 Lafayette Street, corner of Leonard, being one block east of Broadway and four blocks north of City Hall Park. Lafayette Street, formerly Elm, extends from Reade Street to Astor Place, and is the route of the Subway from Worth Street to Astor Place. It will be noted that one of the kiosk entrances to the Subway shows in the accompanying illustration at the right of the first building beyond, and in the distance is seen a portion of the roof of the magnificent Hall of Records, recently completed. The new location is one of the most convenient in downtown New York, being near the Brooklyn Bridge and the Subway, which latter already gives quick communication throughout the length of Manhattan Island and beyond. Later it will communicate directly with the Brooklyn Subway, and the great Hudson Tunnel system.

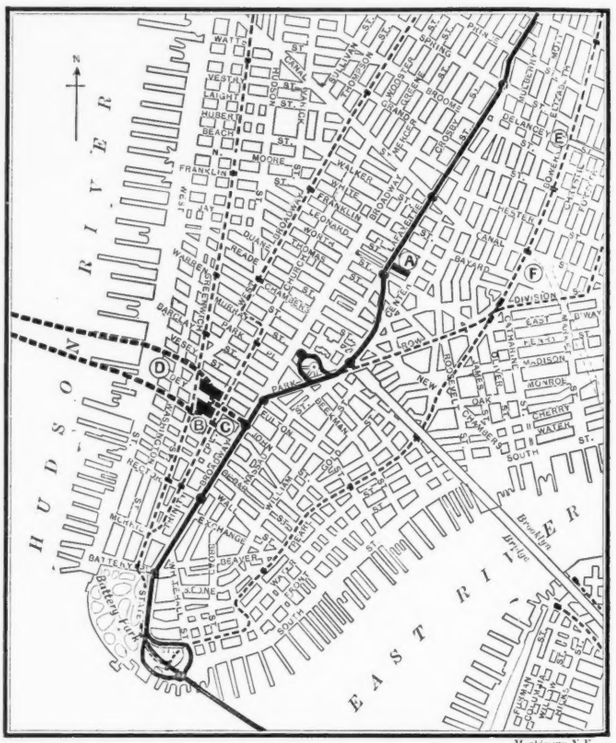
This part of the city is of considerable historic interest. It is near the site of the old "Collect," a pond which for a brief time about one hundred and thirty years ago was the city's water reservoir, and later became a dismal and dangerous stagnant pool, in which the town people threw dead cats and dogs—and sometimes men as well. The real estate within a stone throw's radius of the site of the old pond is to-day valued far up in the millions.

The building is a good example of modern skyscraper construction, being fireproof and especially adapted to our requirements. A ten-year lease has been taken of the eighth floor, having an area of 6,500 square feet, which we hope will accommodate our business for some years to come, although a continuation of its proportionate growth during the past fifteen years may oblige us to take additional space before the termination of our lease. The central location, which is shown on the map in the next column, makes it convenient for all our friends who visit New York to call on us, and we extend to them a cordial invitation to do so.

THE MACHINERY AND METAL CLUB.

The demolition of the two blocks bounded by Cortlandt, Dey, Fulton and Church Streets, in the center of the machinery district of New York City, to make room for the Hudson Tunnel Terminal Buildings, dislodged a large number of firms in this trade; and on account of the difficulty of obtaining warerooms, a number of them contemplated moving uptown on the theory that proximity to the hotels would prove a convenience to visiting buyers. The fact that a move of this kind would result in spreading the trade over a wide area was lost sight of.

The great advantage to the machinery trade of continuing in its present central location, which can be quickly reached from every point, was at once seen by Mr. Francis H. Stillman, president of the Watson-Stillman Company, who set about the organization of a Machinery and Metal Club that would both fill an existing want and help to insure the continuation of those trades in their present location. In response to a circular letter sent out by Mr. Stillman a large meeting of those interested was held early last month, and an organization committee appointed to take the necessary steps for the formation of the club, the success of which appears to be assured, as more than four hundred applications have been received by Mr. Stillman alone, which number does not include other names received by members of the committee. An option has been secured on two floors of the Fulton Building,



Map showing Location of the Hudson Tunnel Terminal Buildings and also of MACHINERY'S New Offices.

A.—MACHINERY'S new office. B.—Hudson Tunnel Terminal Building. C.—Subway Foot-path under Dey Street. D.—Hudson & Manhattan R. R. Co.'s Twin Tunnels. E.—Approach to the new East River (Williamsburg) Bridge. F.—Approach to Manhattan Bridge, now building.

one of the buildings forming the great terminal property which will be practically the center of the Subway and tunnel system of New York and vicinity. The map on this page shows at a glance the convenience of the location and its accessibility to various points in and near New York.

In connection with this movement, Mr. Stillman has also in mind the erection of extensive warehouses at the Jersey City end of the tunnel, which will be but a few minutes from the Terminal buildings, and which will afford ample storage and show room facilities at a far lower rental than can be obtained on Manhattan Island.

* * *

A good mechanic will not use a hammer and set to tighten or loosen a nut, but it would be a very poor mechanic who would not know enough to use this handy expedient in an emergency if a wrench were not at hand.

LETTERS UPON PRACTICAL SUBJECTS.

METHOD OF REPAIRING TWIST DRILLS WITH BROKEN TANGS.

The object of the accompanying cuts is to show how I propose to get out of doing one of the most unwelcome jobs as it is usually done by substituting a method which will not only save the necessity of turning up the shanks of this pile of drills, but which will prevent a similar pile from ever being sent into the tool-room for shank repairs again. To the right in the cut, Fig. 1, will be noticed sockets or collets having been made with a flat section running the entire

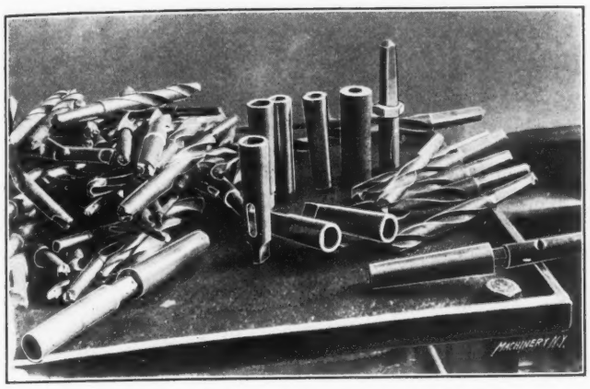


Fig. 1. Collection of Drills with Broken Tangs, and Sockets for Repaired Drills without Tangs.

length of the taper hole. A corresponding flat is made on the shank of the drill. I have demonstrated by actual test that the drill will break before allowing the shank to twist. The manner in which these collets are made may give some sensitive tool-room autocrats a shock, but nevertheless excellent results can be obtained by the method adopted.

First, take a bar of machine steel about 3/16 inch larger than the large end of the collets to be made. If you can do this job in a turret lathe, so much the better; if not, cut up the bar in lengths to suit the collets being made, drill a hole

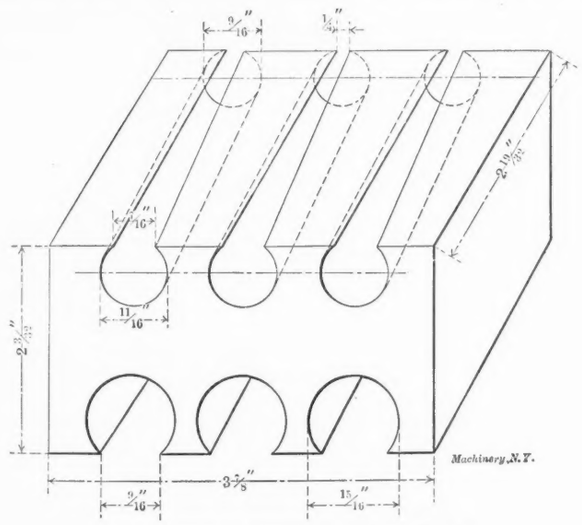


Fig. 2. Device for Milling Flat on Taper Shanks.

in the blanks about ¼ inch deeper than the length of taper shank of the drills, and 1/32 inch larger than small end of the drill shank. Then make the two taper drifts shown in Fig. 1. One should be smaller than the drill shank and have a less steep taper; the second one should be made the same size and taper as the drill shank for which the collet is to be used. Heat the blank and drive in the first drift, and use the flattener to form the flat section. Then remove the drift, reheat the blank, and drive in number two drift up to the shoulder, using the flattener again to complete the formation of the flat section of the hole. If ordinary care is exercised by the toolsmith an excellent job can be made. After the hole has been polished up, and the outside of the blank turned, it will keep some men guessing as to how it was made. The blanks are now turned up on the special arbor shown. The nut is used to take them off the arbor after having turned them.

Fig. 2 shows a milling fixture used for milling the flats on the drill shanks, three or more at a time, which scarcely requires any explanation. The taper holes are made to suit the various sizes of drill shanks, and afterward cut away to allow the shanks to project the amount it is desired to mill off. I have found that for number one Morse taper shank a 5/16-inch wide flat at the large end is about right; for number two taper shank, 7/16 inch, and for number three taper shank 9/16 inch wide flat is correct. By starting the milling cutter at the large end and feeding toward the small end, this fixture works very successfully, and I have had all the drills in the shop milled for these sockets, so that I believe there will be no more broken drill shanks to repair here. I would specially recommend these sockets to be used where drilling is being done with air motors, as my experience is that far more tangs are twisted off in air motors than in machines. OBSERVER.

SPRING COLLET FOR HOLDING WORK BY THE INSIDE.

The accompanying cuts show a spring collet which I have made and used in reboring brass bushings which have been pressed into a casehardened clutch. Part *A*, Fig. 1, is the clutch and *B* the bushing. The clutches are made of machine steel, and are a combination roller ratchet and clutch. The section at *C* shows the roller race. Now we find that after

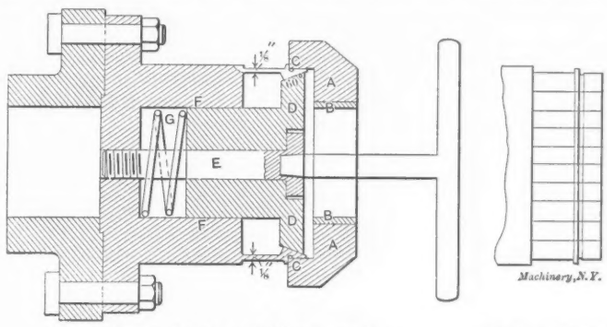


Fig. 1. Spring Collet for Holding Rings, Etc., by the Inside.

Fig. 2. Slits Cut in End of Collet to produce Spring Action.

casehardening, the clutches change their shape considerably, some more than others. The roller races, though bored very accurately to plug gage, vary in size after hardening, from 0.002 to 0.012 inch in diameter. Nor does the bore of the clutch into which the brass bushing is to be pressed remain true with the roller race, which is important, as it should be as near right as possible.

The company does not care to spend the extra time and money that it would cost to grind the bore and roller race to exact diameters, true with each other, so we rebore the bushings after they have been pressed into the clutches, using the collet shown in the sketch to hold the clutches during the operation. The variation in diameter of the roller race, as stated above, prevents our using a solid plug for locating the clutch, but the variations do not injure the clutch, it being important only that the roller race should be concentric with the bore of the brass bushing, which is the bearing. We have found our method very satisfactory, as no time is lost in chucking. We move the taper plug *D* in or out by means of the screw *E*. This takes up the variation in the diameter of the bore of the roller race and holds the piece securely with very little pressure, and after the bushings are rebored, they are found to be very nearly true with the roller race. In boring the bushings, after the boring tool is once set to bore the hole to proper size, the gib is tightened on the cross carriage and a great many are bored without changing the tool. The bushings are bored to a running fit. They are finished all over before pressing into the clutch, except the bore,

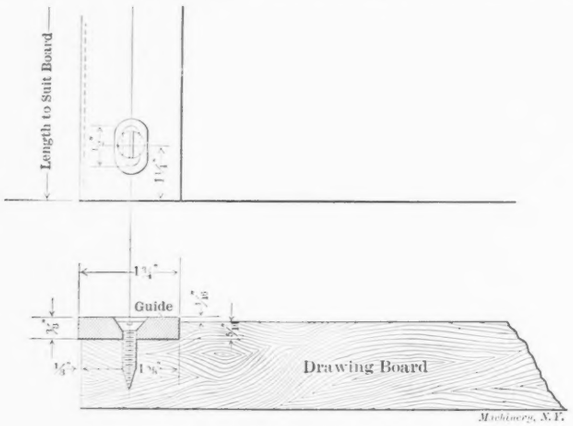
which is left about 0.010 inch large to allow for reboring. I hardly think the jig needs much explanation as it is shown quite plainly in the sketch. The plug *D* is a close fit in the body of the jig at *F*, and *G* represents a coil spring. The horizontal lines in Fig. 2 represent the slots sawed with a hacksaw.

R. B. CASEY.

Schenectady, N. Y.

GUIDE STRIP FOR DRAWING BOARD.

A great many draftsmen are quite frequently troubled by lines drawn with a T-square not being parallel with each other at different points of the drawing board. This is in-



Guide Strip for Drawing Board.

variably due to the fact that the edge of the drawing board is seldom true. This trouble may be easily overcome by the application of the T-square guide shown in the cut. The left-hand side of the drawing board is cut out 5-16 inch deep by 1⅝ inch wide, the full width of the board, and a bar of steel ¾ inch by 1¾ inch, length to suit, is inserted; the latter is secured by four screws, the holes for the screws being oblong to allow for any expansion or contraction of the draw-

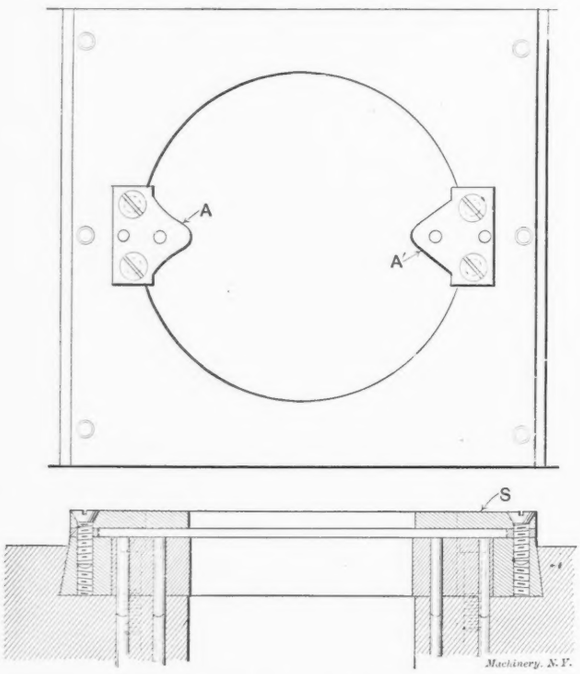


Fig. 1. Die for Outside of Blank.

ing board. This guide, projecting ⅛ inch from the edge of the board, gives a smooth surface for the T-square head and projecting 1-16 inch above the board, as shown, tends to keep the T-square blade just enough above the paper to keep the drawing paper, which is very often soiled by the shifting of the T-square, reasonably clean. Parallel lines at all points on the board are insured by the application of this guide.

Meadville, Pa. J. C. HASSETT.

SECTIONAL PUNCHES AND DIES.

The punches and dies in Figs. 1, 2, 3, and 4 were made for producing the punching Fig. 5, in two operations, and illustrate to some extent sectional die making. As a perfect punching was required in regard to the inside and outside diameters, the design shown was adopted, which proved to be all that could be desired as to accuracy and cost of making, particularly when compared to previous methods and results. In making the punch and die for the first operation, Figs. 1 and 3, the punch was made first. *B* is the punch proper, and *C* is the holder which is made of cast iron. The punch was hardened and screwed and doweled to the holder before grinding the outside diameter to the correct size. Then the die was machined, and after hardening ground to fit the diameter of the punch. The sections *A* and *A'* were then fitted to the die and fastened with the screws and dowel pins as shown, and sheared with the punch. As the sections *A* and *A'* were small, they did not alter any in hardening.

For the second operation, the punch and die, Figs. 2 and 4, were made in the same way, that is, the punch was hardened and ground on the diameter *D*, and the die ground at *E* to fit

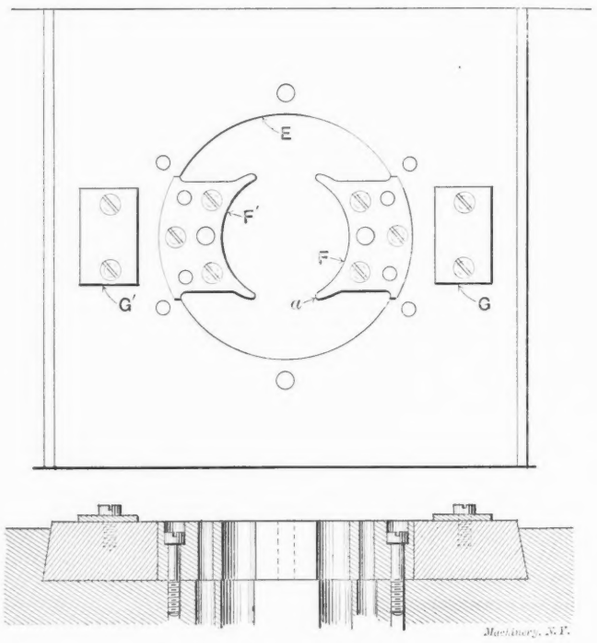


Fig. 2. Die for Inside Shape and Holes.

diameter *D*. The sections *F* and *F'* were then machined in the proper way and sheared by the punch. In hardening the sections *F* and *F'* one of them altered so much at *a* that it had to be discarded and another made. This could have happened had the die been made solid, which would have condemned the whole die, and a new die would have had to be made. The rest of the design is readily understood by referring to cuts Fig. 1, where *S* is the stripper, and Fig. 4, where the stripper is on the punch, the blank being placed on the die guided by strips *G G'*.

A. C. L.

DOES A TECHNICAL EDUCATION PAY?

Your readers may remember that an article, "On the Object of Technical Training," was published in the February issue. This article brought forth a letter from a young man, a student at one of the larger technical colleges, and a man absolutely a stranger to me. From this letter I make a few extracts with his permission:

"My case is a typical one. I carried papers and swept in the high school and have waited on table, washed dishes, pulled weeds and worked in our library to keep myself in an engineering school. I read everything I can relative to engineering education and its faults, the outlook as portrayed by the engineering press throughout the country is indeed not very encouraging. . . . If our severe critics could see the hardships that some of the boys put up with—how they deny

themselves sleep, recreation, good health and even live on two meals, they would be a little kindlier in their criticisms."

This boy's picture of his life is not an unusual one; there are great numbers of boys who are wholly or partially earning their way through colleges. Does it pay? Is it worth the sacrifice? The question of whether technical colleges ought to make changes in their work does not affect this case; the only thing to be considered is whether taken as they are, they do a young man enough good to pay. From a money point of view there is not much room for doubt that these chaps almost invariably do well after they have been out a few years. During the first two or three years after graduation is the time when we hear the most criticism. After that they lose in a way their individuality as college men and take their stand among men purely on their own merits. It is only after they have made this change that their employers entrust to them work of sufficient importance, so that they can really use the education they have received. Before that time they are really again freshmen in the school of life, and must expect to be hazed more or less in the same way that they were when they were freshmen in college. When you run across a man in the shops, or on the road or in any engineering work after he is 30 or 35 years old, it is hard to guess whether he came up to his job through the shop or from an engineering school. If that is so, then why is it any better for a boy to go through a college rather than through the shop? My answer is just this: The college road is shorter and is more likely, using the same raw material, to succeed. The shop educated boy learns certain things regarding actual work, use of tools, handling work, etc., better and more thoroughly than the graduate. But if he learns anything of mathematics, of drawing, of design, he does it at a sacrifice of time and strength at least equal to that which the college boy without money may make. He must learn at night and without a teacher at his elbow. He cannot have the advantages of a laboratory, and that is a serious drawback, but he must dig out a great deal for himself, which is an advantage. Again, as a matter of fact, young men 18 years to 21 years old—the time when most boys are in school or are apprentices—are at the age when their minds are most receptive of new facts, yet are at the age when they will not voluntarily make the effort to reach out for new ideas, from books at least. The man in the shop who wakes up to the situation and begins to study from books is usually at least 25 years old when he does it. He has lost his power to study easily, and he is in too much of a hurry to get to something, the use for which he can see, to spend much time on preliminaries and fundamental work. The college boy has this advantage, that in order to stay in school at all, he must go through that preliminary drudgery whether he will or not. He comes out with a mind trained to look at problems in a logical way, but without the ability to take short cuts in the solution of problems which have been of everyday occurrence to the shop man. The chances of a given boy of 18 years amounting to anything in an engineering way are better by the school method than the shop method to-day (the writer believes that the shop method is susceptible of such great improvement as to at least equalize the two, but that is apart from this discussion). The boy may do just as well by the shop method, but it depends more on himself than in the school. The fact that in a school he is associated with other learners and with men whose business it is to teach, and where he has constant incentive to study, is very different from shop associations where there is every incentive to let his study go. If some technical school could make arrangements with some manufacturers or engineers to take their product and work them hard and hide them away for two or three years and only let them out and give them their degree at the end of their practical course, then the reputation of that school might grow, but it would serve no practical purpose better than the present system. It would simply do away with the chance which so-called "practical men" have of making fun of the green technical graduate, because he would be kept in a dry kiln to season for a year or so, instead of being stacked out in the open where everyone could see the sap ooze out.

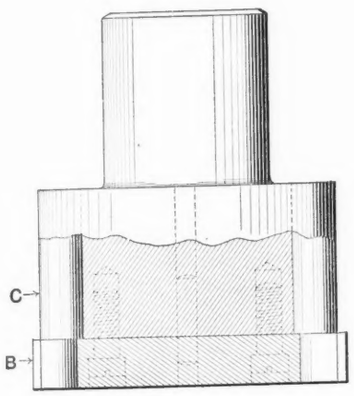


Fig. 3. Punch for Punching Outside of Blank.

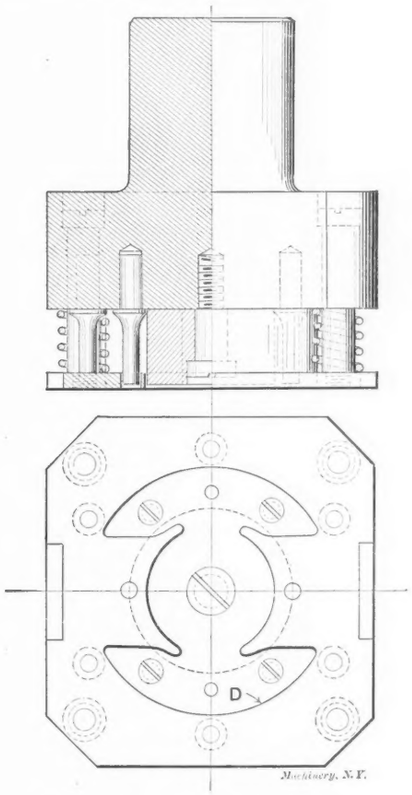


Fig. 4. Punch for Inside Shape and Holes.

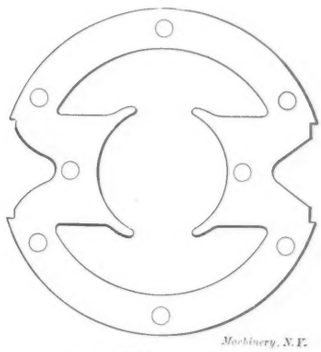


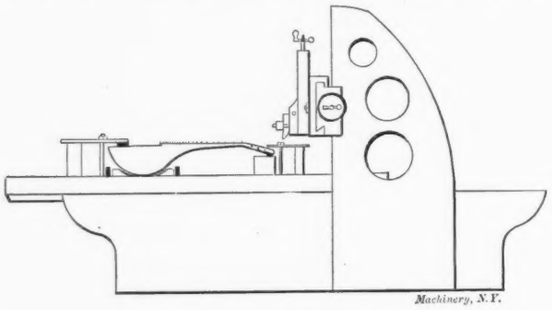
Fig. 5. Finished Punching.

One other word to any young men who are making sacrifices to get their education. You cannot get anything in this world without making sacrifices. When you get rich you have got to keep straight. You have to remember that you are up where everyone can see you. You are not independent. You cannot be. It is just as hard to do things that you do not want to just because it will make talk if you do, as it is to go hungry. When you have the money to buy privileges which the law says you shall not have, it is no easier to obey the law than it is to go without sleep. You are going to have just about so hard a time just so long as you live. By-and-by you will get used to it and will appreciate any little let-ups that fortune may give you, and when things are going hard you may be thankful that there is such a thing as work in which you may lose yourself, and when things are bright, be thankful that there is work which must be done to keep you from having idle time to put you to your wits' end for something to do for amusement.

ENTROPY.

A MUSICAL JOB.

Once I was "holding down a job" in a little repair shop, where I was everything from a casting cleaner to toolmaker. A chap brought in a mandolin one day, and said that the frets were too high. He had been filing them one by one, but could not get them level. As soon as he got one lower than the next, the thing would sound like "The Call of the Wild" or anything but the note desired. The boss told me to "see what I could do." I looked it over and told the chap I would do it in two hours, which meant $1.50 to him. He appeared to want to hang around and see how I went at it, but I had an idea and didn't want to be bothered by too many sugges-



Planing Mandolin Frets.

tions, so I told him I would not be able to start for some time, and he went off with the intention of returning before I began. As soon as he was out of the door I measured the fingerboard and found that it was 9½ inches, or 3 inches too long for the small old shaper, so I clamped it on a 6-foot planer with wooden straps and layers of cotton waste, and in fifteen minutes I had a couple of fine cuts across the brass frets and the job was finished with a few strokes of a fine file on the edges, rounding them to avoid taking chunks of meat out of the player's fingers when he surpassed himself in the flights of harmony.

Our customer was much surprised when he returned to find his instrument lying finished on the bench, and after "stringing it up" he gave us a couple of jigs, and appeared satisfied with the result. He wanted to know how it was done, but I evaded answering, fearing he might imagine I had injured the frail instrument by clamping it, although I had not used a wrench with a 4-foot pipe on the handle. Next day Jimmy, an apprentice, informed me that he had told the chap I had "bitten" off the desired amount. Although I scarcely think this was swallowed, nevertheless there doubtless hangs a cloud of mystery around the fingerboard of that instrument.

W. L. McL.

AN INGENIOUS APPRENTICE.

In a small shop in a city in southern Pennsylvania, there worked a lad of about sixteen years of age. The line of work carried on in this shop was rather general in its character, including the manufacture of steam engines, pumps, boilers, etc. This was no unusual state of affairs, however, in the latter part of the sixties, as almost every shop was more or less of a general repair and job shop.

A man came to the shop one day and asked to have a number of egg-shaped weights made, to be cast of cast-iron and to weigh exactly 12 pounds. The owner and foreman of the shop was somewhat at a loss as to how he should go about making a pattern for the job. His knowledge of higher mathematics did not permit him to make "any accurate calculations." During the day, he spoke to Frank, our young apprentice, of the job and asked him what he thought of it. Heretofore, he had seen that the lad possessed some genius and he determined to try him again. He said, "Frank, I would like to have you make the pattern for that job, if you can." The lad only said, "Well, Mr. Johnson, I can try." Then Mr. Johnson turned and walked away leaving Frank to himself. The boy looked at the order as to what was required and sat down and studied the proposition over. After a few minutes' deliberation, Frank set to work. He constructed a box 4 inches by 4 inches by 3 inches inside dimensions. This he filled with moulder's clay, having just 48 cubic inches of clay, and started the shaping of the clay into an egg. Having carefully shaped the clay until it was about the desired shape, he put it in the coke oven and baked it. After the egg was baked, he took it to the pattern shop and proceeded to turn up his pattern using his clay egg as a guide. Carefully calipering the pattern and being sure that it was a true duplicate of his clay egg, he sent it to the foundry. A casting was made that afternoon, and on its being dumped and cleaned up, it was found to tip the scales at exactly 12 pounds, the desired weight.

On seeing the casting made as required, Mr. Johnson's curiosity got slightly the better of him and he asked Frank just how he did the trick, and he had the whole thing carefully explained to him. The apprentice assumed that by taking the weight of cast iron to be 0.25 pound instead of 0.261 pound per cubic inch, he would have sufficient bulk of clay to allow for shrinkage in drying or baking the clay, and also for shrinkage in the casting. His assumption was only arbitrary, but it happened to work out all right, and that was all that was to be desired.

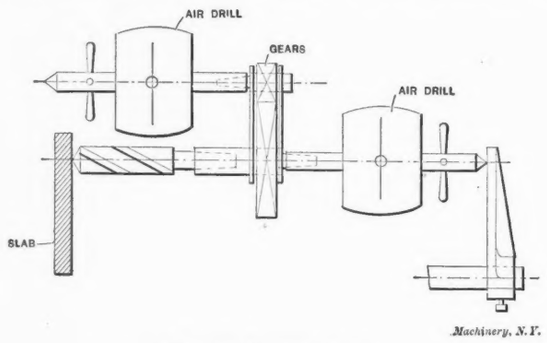
As a consequence, it so happened that before this lad had finished his actual apprenticeship, he was placed in charge of the machine shop. The true genius of the boy was early recognized and to-day Frank holds quite a responsible position as designer.

J. J. JENKINS.

COMPOUNDING AN AIR DRILL.

We had some 2 15-16 holes to drill in an inch-and-a-half slab, and as it was a repair job the work had to be done in place, using an air drill. We started in one Sunday morning with the largest air drill obtainable, which was intended to drill 1½-inch holes at the maximum. And that drill didn't allow the original intentions of its designer to be perverted, either. To begin with, the throttle was out of order, and we could neither start nor stop it except from the valve at the air plug, way across the mill; when the man at the drill and the man at the valve finally got the word together, it started off nicely for a few minutes, until the overload became too great; then there was a short imitation of an automobile going up hill, and silence, with an accompanying lack of rotation on the part of the drill. The boss looked it up and decided it would have to go to the shop for repairs; by the time he got a ratchet and half a dozen "Hunkies" on the job it was 5:30, and we went home.

By the next Sunday (the only day in the week that the mill shut down) we had rigged up two air drills as shown in the sketch, gearing them together; this was done by keying two gears, in the ratio of three to one, on the drill sockets, with a steel plate on each side of the gears to keep the proper center distance and bind the tools together. The main air drill, that



Compounding an Air Drill.

is, the one in line with the drill itself, was held in place by an "old man" and fed in the ordinary way; the other, the upper one in the sketch, was lashed to the first with ropes, twisted tight in order to get the necessary pull. Half-inch holes were first made in the slab with a single drill, and the new apparatus put into commission. After a little experimenting it took hold and put those 2 15-16 holes through just like an up-to-date radial would have done it in the shop.

Of course the full power was not gotten out of the direct-working air drill, as it could not work up to the limit of its speed; but the work was done, and that was all we cared about.

BESSEMER.

SCALE OF CHORDS.

The accompanying cut shows a handy and accurate scale for laying out and determining the size of angles. It is made so that in a circle with a radius equal to the distance 0 to 60 on the scale, the distance from 0 is the chord for the equivalent angle. If a is the angle in degrees, the chord $= 2 \sin \frac{a}{2}$, if the radius is considered to be the unit of length. This is the formula by which the scale was constructed. The method of using the scale is as follows:

Take 0—60 as radius and describe an arc; then draw a line from the center to any point on the arc. With a compass set to the proper figure on the scale, and with the point of intersection of the radius with the arc as a center describe another arc which will intersect the first. From the point of intersection draw a line to the center. The angle between the two radii will be the required angle. To find the number of degrees in a given angle draw an arc as described above, using the vertex as a center, and with the scale measure the distance between the two points of intersection, prolonging the sides of the angle if necessary to intersect the arc.

Holyoke, Mass. F. E. PETTERSSON.

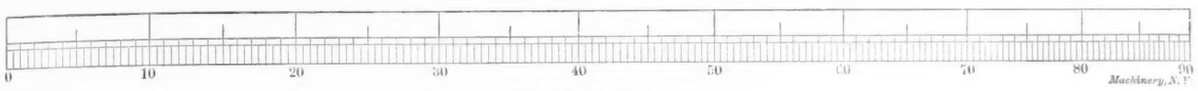


Fig. 1. Scale of Chords.

[This is a good example of the way old ideas sometimes turn up in new form. The scheme, of course, constitutes a scale of chords, a draftsman's tool which formerly had a much greater use than now when it is largely displaced by the more convenient protractor. The following method for making a scale of chords is copied verbatim from an elementary work on surveying (Davies), published in 1834:

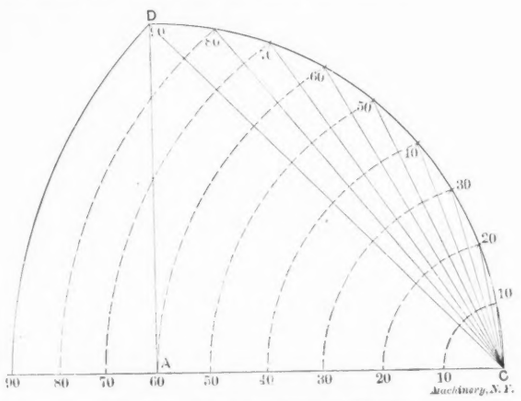


Fig. 2. Laying Out a Scale of Chords.

"If, with any radius, as $A\,C$, we describe the quadrant $C\,D$, and then divide it into 90 equal parts, each part is called a degree. Through C and each point of division let a chord be drawn, and let the lengths of these chords be accurately laid off on a scale; such a scale is called a *scale of chords*. In the figure the chords are drawn for every 10 degrees."—EDITOR.]

AN ANSWER TO ENTROPY.

Entropy's criticism, in the April issue, of your editorial on "Principles of Rational Design," is very well written and suggestive, but the sentiments he gives voice to remind one strongly of the complaint of the youth who hated to wash his face because it got dirty again so quickly. Because the ideal is unattainable, does Entropy wish us to cease our struggle for it? A near approach to the ideal is not quite so unattainable as he would have us believe. Without doubt the designer referred to in your editorial was thinking principally of machine tools when he spoke, in which the conditions governing design are as well known and as fully recorded, probably, as in any other line of machinery. As a protest against careless designing and slovenly neglect of recorded information, the editorial was timely, as any one having experience with the usual drafting-room methods can testify.

To show that I am not prejudiced in this matter by a tendency to class myself with those ideal designers who can work out a design automatically, by pressing the proper keys and turning the crark, I will relate a little incident that occurred when I was engaged in the design of a certain automatic machine which dealt with materials whose characteristics were unfamiliar to me. The case is, in a way, parallel to that which Entropy mentions.

The machine in question had, as one of its functions, the gluing together of two pieces of cardboard. To apply the glue, the cardboard was carried along tangent to the rim of a narrow wheel or disk, which revolved in a pot of heated glue. The cardboard thus took off from the wheel a band of glue of the required width. This glue, however, acted about as glue might be expected to act under the circumstances. When the card left the wheel the glue did not immediately separate, but strung out into a fine thread or "whisker" as we used to call it. These "whiskers" floated along through the air until they met a cross bar of the machine, where they congregated, and in the course of time formed a full beard as it were, with "side taps" too, if left to themselves too long. The machine was, in fact, continually mussed up and clogged up from end to end with this sticky, semi-solid glue.

We at once began to worry over the problem of preventing this trouble. Finally we hit on a scheme of placing a roller just under the card as it left the wheel and almost touching it. This roller was revolved at a high rate of speed in a direction opposite to that at which the card was traveling, and in a very satisfactory fashion pulled the whiskers out by the roots before they had time to grow to any size. So we solved this difficulty—but were met with another one. How were we to remove from the roll the glue thus wound up upon it? After thinking the matter over without sleep or food for five nights and two days, we hit on the plan of putting a scraper close to the roll, and on this the glue was collected before it had time to freeze solid. Eureka! It worked! The inventor and I shook hands with each other and decided that the question was solved. A freckle-faced apprentice boy who was standing by, however, asked how we were going to get the glue off the scraper. Our crests fell at once, and we retired to meditate on this new problem.

Leaving the inventor and designers with their troubles, let us follow the apprentice for a while. He strayed out to the dump at the back of the shop, selected a properly proportioned and well preserved tomato can, and punched a small hole in its bottom. This he plugged with wood, leaving just room enough for water to come out a drop at a time, semi-occasionally. The boy next hung this over the scraper which collected the glue from the roll, which collected the whiskers from the card, which took the glue from the wheel, which brought it from the glue pot; then he started the machine up. The wheel took the glue up, and applied it to the card, the roll removed the incipient whiskers and transferred them to the scraper, and the water, dropping gently and unostentatiously on the scraper, dissolved the glue as fast as it accumulated and allowed it to drop back again into the pot. And thus was the problem solved. R. E. F.

INSERTED BLADE TURRET TOOLS.

With the advent of high speed steel comes the necessity of making tools with inserted blades, owing to the high price of high speed steel. In the illustrations are shown some of these tools which have been used with great success. In making tools of this description it is always best, except in large sizes, to make them of tool steel, as they have to stand for hard usage. The cost of making is a little more, but is offset by the length of time they will last. Another advantage which is deliberately ignored by many, is in the use of hardened tool steel setscrews for holding the blades. Where a screw has got to be set down hard six or seven times a day something is wanted that will hold. I have seen tools of this kind come

into the shop with casehardened soft steel screws, which would be broken off inside of a week. It's a mighty good man who can drill out a screw and retap the hole in less than half an hour's time, and that half hour would have paid for a tool steel screw which would be good for any number of years. If soft steel screws do not break, they flatten on the end and cause trouble. Tool steel screws up to ⅝ inch

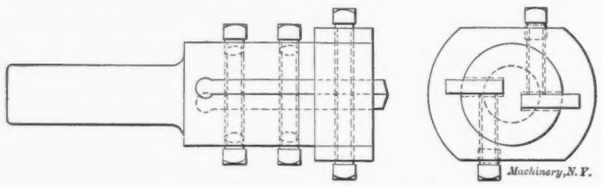


Fig. 1. Inserted Blade Facing Tool.

can be made in the lathe in lots of 50 by an ordinary lathe hand for 12 cents apiece, and those 50 screws are equal to 500 made of soft steel.

Wherever I can use a through bolt instead of a cap screw for holding tool blades I always do so. In that case soft steel has the advantage of being the cheapest, for when a bolt breaks, it can be replaced in two or three minutes. In regard to the tools themselves, Fig. 1 is a squaring tool using flat

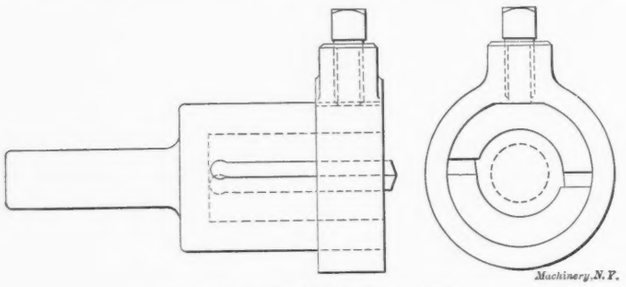


Fig. 2. Inserted Blade Hollow Mill.

stock for blades. Fig. 2 is a hollow mill which will stand up under very coarse feeds. As shown it would only turn the length of the tool body, but in a turret which would take a large shank longer work could be turned by making the shank hollow. Fig. 3 is a combination tool which counterbores, countersinks, and squares the end of the work. Made with a taper shank it can be used to good advantage in the drill press. This tool is somewhat special but the idea can be car-

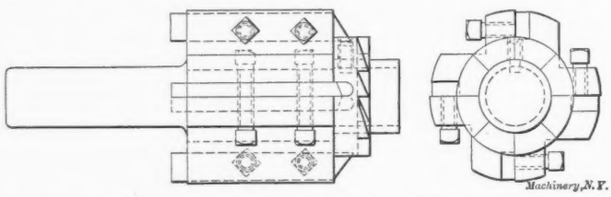


Fig. 3. Combination Counterbore and Countersink with Inserted Blades.

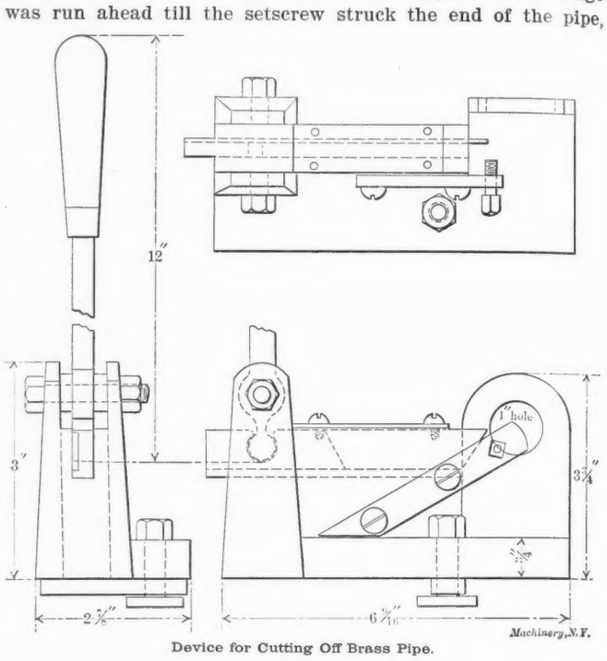
ried out in a great variety of ways. Different sizes of pilots and counterbores can be used, and the blades can be ground to different shapes.

PAUL W. ABBOTT.

Lowell, Mass.

DEVICE FOR CUTTING FERRULES.

The cut herewith shows a device I made some time ago for cutting ferrules in the factory where I was superintendent. We used thousands of ferrules cut from 1 inch outside diameter brass pipe. We had tried several different ways to cut them, but they all took too much time, and as these ferrules must be accurate for length, from 5-16 to ¾ inch in length, I finally conceived an idea for making this tool. We had a 13-inch by 7-foot lathe with a 1 1-16-inch hollow spindle, so we bought the pipe in 16-feet lengths, and by using this tool instead of the tool-post, the 1-inch hole being central to the center of the lathe, we were able to cut from 80 to 100 ferrules at one setting. The cut explains itself. By putting the pipe through the hollow spindle and holding it in a universal chuck, it was possible for a boy to cut about 75 to 100 ferrules per minute. It may be seen that by running the end of the pipe in the 1 inch hole which acted as a steady rest, and adjusting the stop screw in the stop bar, all that was necessary was to pull the hand lever which works the cutter bar. The ferrule was cut off and dropped out of the way, and the carriage was run ahead till the setscrew struck the end of the pipe,



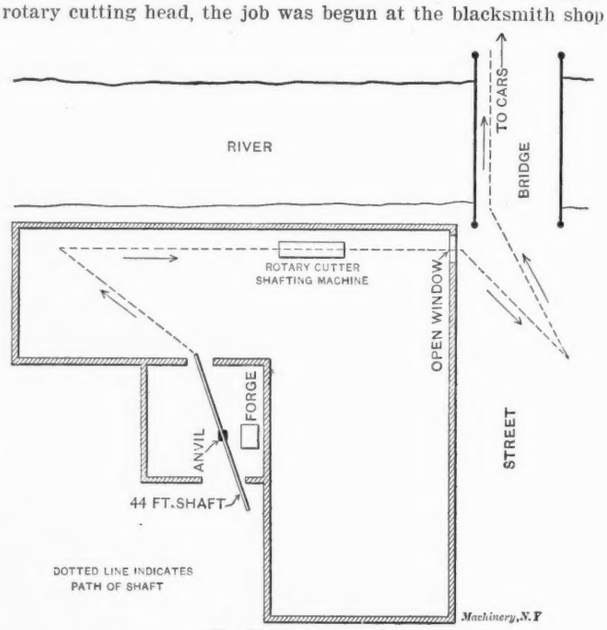
Device for Cutting Off Brass Pipe.

thus setting the tool for another cut. The cutter was made from 1-16-inch self-hardening steel, and by grinding so that the outer edge was a trifle ahead so that it would cut through first, the pipe was cut so that there was practically no burr at all. We also found, when making bushings of different sizes, that this was a very desirable tool. The plant where I am now employed is making a large tool like this for cutting off large shafting, bridge pins, and gas pipe ferrules, etc.

A. L. F.

HANDLING A LONG SHAFT.

Some time ago a New England shop received an order for a 2½-inch shaft, 44 feet long, and free from couplings. As the shop was equipped with a shafting machine having a rotary cutting head, the job was begun at the blacksmith shop



Handling a Long Shaft.

by welding together two 22-foot shafts. The path of the shaft after leaving the anvil will be seen by referring to the diagram. The shaft was run through the open window and into the street after being turned, and was received by twelve men who carried it to the platform cars, two cars being necessary, owing to the excessive length of the shaft.

WM. C. TERRY.

Boston, Mass.

ANSWERS TO W. J. B.'S PISTON TROUBLE.

In answer to W. J. B.'s inquiry in the March issue I would say that the trouble might be caused by the method of heating. If the piston was heated through the hole, as the quicker way, the rim would not expand as fast as the center and this would cause the hole to close up. If the rim were heated first, allowing it to expand while the heat worked toward the center there would be no trouble. I have seen holes in rolls for boring mills, bored 2 15/16 inches, heated in the bore, and when cooled off the holes were from 0.002 to 0.003 inch smaller than when first bored. I. J. P.

Referring to the question of W. J. B. in the "How and Why" department of March, I would offer the following explanation The metal surrounding the hole was probably heated to a much higher temperature than the remainder of the piston. The hollow heated metal would expand in the direction of the least resistance or toward the hole, being prevented from expanding in the opposite direction by the resistance of the cooler surrounding portion. I had the same trouble when preparing parts for shrink fits, but the trouble disappeared after allowing the piece to be uniformly heated.

Alliance, Ohio. E. D. GAGNIER.

Answering W. J. B.'s inquiry regarding the behavior of a certain 22-inch piston, I would say that the hollow form of piston had nothing whatever to do with the contraction of the hole after heating. Probably the piston was not heated properly, that is, uniformly all over. Heating the piston around the hole only does not enlarge the hole, but rather tends to contract it on account of the high resistance of the cooler metal outside. I would say that the allowance for the fit was about three times too much; 0.002 inch per inch of diameter is the maximum allowance in good practice.

Scottdale, Pa. M. B. STAUFFER.

In answer to W. J. B.'s experience with a piston rod not entering the piston after it was heated, would say that I had a similar experience. When working in the Santa Fé Railroad shops about six years ago, I had occasion to fit a piston rod to a piston and made the usual allowance for shrinkage. I informed the roundhouse foreman that the rod was ready to be shrunk in, and he sent some wipers over to the back shop to get the rod and head. In about an hour he came to the back shop roaring like a Kansas cyclone and informed my foreman that I made the rod too tight a fit, for he could not get it in the piston after he had heated it red hot. I maintained that the rod was fitted O. K. and that if I could not put it in, I would eat it. So I went over to the roundhouse, heated the piston evenly all over, laid it on the floor and dropped the rod into place.

After quizzing the roundhouse foreman, I finally got him to admit that he had heated the piston to a cherry red around the hole while the outside was black. Now, in heating the piston more around the hole than on the outside the heated metal expands lengthwise of the hole while the tension of the outer edge tends to close the hole. In heating a piston carefully all over, the expansion is equal in every direction. I have put on a good many pistons and, following the rule of heating evenly, never had a failure yet on either cast iron or hollow steel castings. J. L. CHATHAM.

Topeka, Kansas.

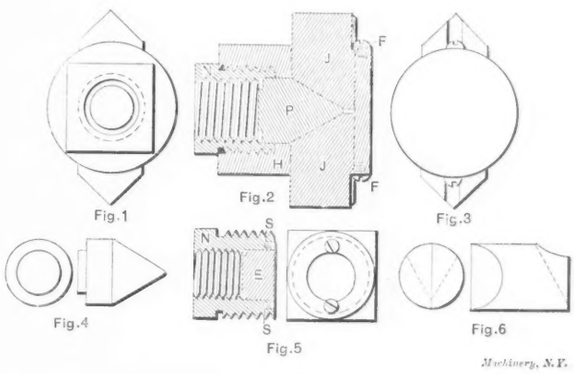
As I read the inquiry of W. J. B. in which he told of his trouble with a piston I was greatly amused, for I was carried back to an old North Texas contract shop where about eight years ago a thing of the same kind happened.

A machinist was given a piston rod to fit in a piston, and when he had got the rod turned, he heated the piston up to a good red heat around the hole. Then he tried to drive the rod home, but it refused to enter. So putting the piston rod back in the lathe he took a full 64th inch off the fit and again heated it, and then with the aid of a 12-pound sledge he succeeded in driving it into the hole where it seemed to be a very tight fit. But, alas, when the piston cooled off the rod rattled around like a shot in a tin horn. This being a break-down job the piston was wanted at once, and the bad fit caused great confusion among the "office push," as the "nut-splitters" expressed it. It is needless to say that this machinist received his time check at once, which was unjust, but he, belonging to the boomer element, had on his clothes and was out of the town before the real cause was located. I have found in shrinking in work that if the castings are made of dirty iron, such as produced by foundries which use much scrap and stove plate, they will often warp, and bored holes will become oval as soon as they are heated for a shrink fit. Shrinking in a rod is something I never do unless my foreman insists upon it, and then the job is done at his risk, not mine. I always drive the rods in if there is no press available, using a little white lead on the fit. A casting will stand as much, if not more, pressure from a rod driven in with a sledge hammer as from cooling down on a cold piece of steel.

Waco, Texas. OTTO P. DOWNING.

STUD HOLDER FOR BOLT CUTTING MACHINE.

The accompanying cut shows a stud holder intended to hold short studs in a bolt-cutting machine when one end of the stud has already been threaded. Referring to the cut Figs. 1 and 3 show end views and Fig. 2 a sectional view of the device. The body *H* is made of machine steel, and is first drilled crosswise to receive the jaws *J*, shown in Fig. 6. These jaws are made in one piece and fastened in place by the screws *F F*. Then the body with this piece in place is chucked and bored out for the plunger *P*, a detail of which is shown in Fig. 4, and is at the same time bored and threaded for the machine



steel bushings *N*. After this is done, the jaws are taken out, cut in two, and the slots for the screws *F F* made a little longer to allow the jaws to freely adjust themselves to the plunger point. The jaws and plunger are made of tool steel and hardened. The square bushings shown can be made of square cold rolled stock and the body of the same kind of round stock, no outside finish being necessary.

The assembled sectional view shows a bushing for 1-inch studs. Fig. 5 shows a bushing for ¾-inch studs. The inside end of the bushing is counterbored for the button *E*, which is a hardened tool steel piece held in place by the two screws *S S*, which prevent it from falling out but allow it to slide in about 1/16 inch the same as the plunger slides in the 1-inch bushing. The threads on the insides of the bushings on all sizes are made the length of the diameter of the stud. The stud to be cut is screwed loosely down against the plunger *P* or the button *E*, as the case may be, and the jaws of the vise tightened up against the jaws of the holder, which in turn force the plunger and, in sizes smaller than 1 inch, the button against the end of the stud, locking it, and also securing the holder in the vise. Opening the vise allows the button, plunger and jaws to go back to their former places, and the stud can be easily removed. M. H. BALL.

Watervliet, N. Y.

* * *

Put not new files on old snags.

Clean wash-ups spoil no dinners.

The $40 tool chest may be that of a 3-cent man.

A stub pencil may write an honest time card.

A file chip in the surface-plate is not worse than a constant borrower.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

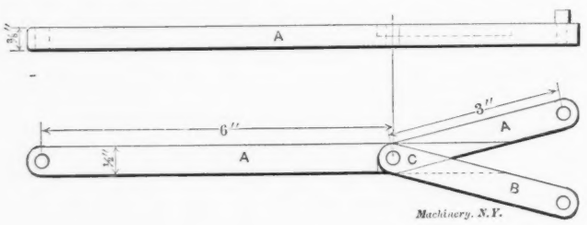
DUPLEX PENCIL FOR RULING PARALLEL LINES.

A convenient draftsman's tool for ruling the two lines with which to determine the correct height of the lettering on a drawing consists of two pencils each with one side planed off and glued together so that the distance between the centers of the leads is the same as the desired height of the lettering. The pencils should be provided with chisel points, care being taken in having both leads extend the same length. This device will rule a double line, giving the proper height of letters, with the same effort required to rule a single line, and save any measuring of the distance between the lines.

Champaign, Ill. E. A. PRITCHARD.

ADJUSTABLE SPANNER WRENCH.

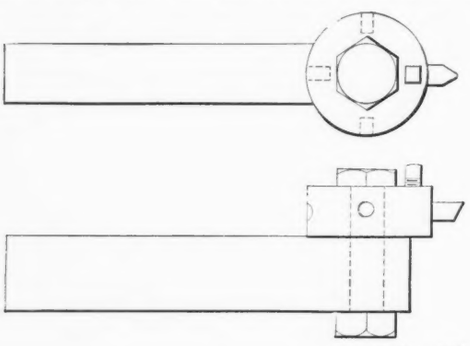
The accompanying cut shows an adjustable spanner wrench which I found of good service. The wrench is for nuts which fit into a recess, and when in place are below the surface. These nuts have holes in the face of them, and as the nuts are of different sizes according to the sizes of the machines they are used for, when the ordinary spanner wrench is used, a different wrench is necessary for each size of nut. In the assembling department the size of wrench needed is usually not at hand, and has to be hunted for, but with a wrench like the one shown in the cut, the hunting (and possibly bad



language) is done away with. As seen from the cut, *A* and *B* are connected at *C*, *B* swinging around a ¼-inch pin as a pivot. The hole at the handle end of the wrench is for hanging it up in a conspicuous place. MACHINIST.

RADIUS PLANING TOOL.

The radius planing kink in the December issue brought to mind a similar job which I ran across some time ago, but one that differed in that a tool held in the tool-post would cut too large a circle. A casting about three feet long was to be grooved to form a half bearing for a journal 2½ inches in diameter, the groove to be parallel to other planed surfaces. While still in the planer the bearing was roughed out to with-

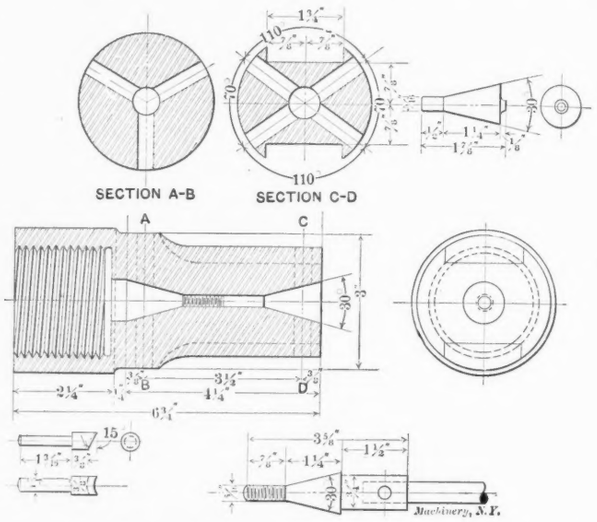


in 1-16 inch of size, and I had the tool shown herewith constructed for finishing. Bolted to the shank so that it could just be turned, was a cast iron head carrying the cutting point. As but one piece was to be machined, feed was given by hand through a long pin wrench inserted in the holes seen in the head, the three holes making it possible to finish the semi-circle with one setting of the tool.

Middletown, N. Y. DONALD A. HAMPSON.

CHUCK FOR AUTOMOBILE ENGINE PISTONS.

The cut herewith shows an expanding chuck intended to hold automobile engine pistons while turning the outside, so that the piston will be held true with the already finished inside bore. The front end of the chuck has a four-point

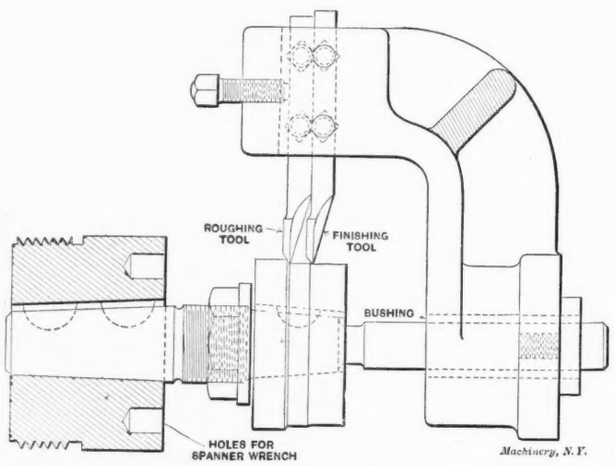


bearing, which is adjusted by a taper plunger forced in by pressing the piston against the end of the plunger. The rear end has a three-point bearing, and the expansion is accomplished by a tapered plunger being screwed in and passing entirely through the spindle. The cut plainly shows the construction of the details. R. H. MITCHELL.

Lansing, Mich.

TURRET TOOLS FOR ROUGHING AND FINISHING PINIONS.

The cut herewith shows a tool which I designed recently for turning and facing pinions on a Warner & Swasey screw machine. It consists of a cast iron overhanging arm carrying a roughing and finishing tool attached in the ordinary way to the turret with two bolts. A cast iron head fitted to the spindle holds the arbor on which the pinion is turned. This arbor is made of tool steel, hardened and ground, and



fitted with Woodruff keys, as shown, to prevent the arbor and pinion from turning on the seat while the cuts are taken. The bushing shown in the arm steadies the arbor during the operation. The hole for the bushing was bored in the machine, bringing it perfectly in line. The tools used are 1 x ½ inch high speed steel cutters. The nut shown is for backing off the pinion after the job is completed. The pinions are first chucked in the same machine, bored, and reamed with a taper reamer. They are then faced on the end with a tool in the cross slide, after which they are put on the fixture shown and turned. Afterward they are faced on the other end to the proper length with a tool in the cross slide.

New York City. C. W. PUTNAM.

SHOP RECEIPTS AND FORMULAS.

A DEPARTMENT FOR USEFUL MIXTURES.

This page is intended to be used only for the publication of such shop receipts as the contributors know from experience to be practicable. Receipts are solicited on the condition that the contributors personally know that they are reliable. The fact that a receipt is old and supposedly well-known does not bar it provided it has not already appeared here.

338. CEMENT FOR JOINING METALS TO WOOD.

Dissolve in boiling water 2¼ pounds glue, 2 ounces gum ammoniac and drop by drop 2 ounces of sulphuric acid.

Birmingham, England. W. R. BOWERS.

339. CHILLING CAST IRON.

Mix together ½ pint of oil of vitriol, 2 ounces of saltpeter, and 3 gallons of clean water. Heat the casting, and plunge it in this solution, keeping it there until cold.

Dayton, O. GEORGE E. HETZLER.

340. CEMENT FOR FASTENING EMERY TO WOOD.

Melt and mix equal parts of shellac, white rosin and carbolic acid in crystals. Add the acid after the other two ingredients are melted. W. R. BOWERS.

Birmingham, England.

341. TO POLISH NICKEL PLATE.

Apply rouge with a little fresh lard or lard oil by a piece of buckskin. Rub the bright parts, using as little of the rouge and oil as possible. Wipe off with a clean cloth slightly oiled. Wipe every day and polish as often as necessary. This is also an excellent preventative of rust.

Middletown, N. Y. DONALD A. HAMPSON.

342. TO PREVENT LEAD FROM STICKING TO THE WORK

To prevent lead from sticking to work that has many small corners or grooves, when heated in a lead bath preparatory to hardening, mix lamp black with water or alcohol to the consistency of paint and apply with a brush. Be sure that the mixture is thoroughly dried out before the piece is dipped into the lead bath. E. W. NORTON.

343. TO PREVENT THE ACCUMULATION OF FOREIGN SUBSTANCES ON TOP OF A HARDENING BATH.

Dust or small globules of oil, which sometimes give trouble by collecting at the top of hardening solutions, can be disposed of by placing a piece of ordinary newspaper on top of the solution; the dirt and oil adhere to the paper and are thus readily removed, thereby avoiding the labor of skimming the bath. EMIL TSCHUDI.

Cincinnati, Ohio.

344. LIQUID FOR ETCHING ON STEEL.

The following solution will be found excellent and reliable either for very deep etching upon steel, or for the purpose of producing beautiful frosted effects upon the surface. Mix together 1 ounce sulphuric acid, ¼ ounce alum, ½ teaspoonful salt, ¼ pint acetic acid or vinegar, and 20 drops concentrated nitric acid. The etching effect produced by this solution depends upon the length of time it is allowed to act upon the metal. It is applied in the same way as ordinary etching acid. T. E. O'DONNELL.

Urbana, Ill.

345. TO BLACKEN BRASS.

Should it be desired to change the color of an article made of brass to a dark bronze or black, the following compound will be found to give good results, especially if the metal has a polished surface. First make up a solution of 120 grains of nitrate of silver and 5 ounces of water; then dissolve 120 grains of copper nitrate in 5 ounces of water. Mix the two solutions together in equal parts, making a quantity sufficient to immerse the articles in. Clean the brass articles to be blackened thoroughly in hot soda water, and then dip in the above compound. Remove and heat in an oven until the proper shade of color appears. T. E. O'DONNELL.

Urbana, Ill.

346. CEMENT FOR FASTENING LEATHER TO IRON.

To make a good quality of glue for fastening leather to iron, as required when covering iron pulleys with leather, etc., the following will be found to be a good receipt: To one part of glue dissolved in strong cider vinegar add 1 ounce of Venice turpentine. Allow this to boil very slowly over a moderate fire for 10 or 12 hours. It should be applied to the surface of the iron, upon which the leather is to be cemented, with a brush, while it is still quite warm. Before applying, the iron surface and the leather should be scraped perfectly clean. Then put on the leather, press it firmly into place and allow to dry for a few hours. T. E. O'DONNELL.

Urbana, Ill.

347. CEMENT FOR LOCOMOTIVE FRONT-ENDS.

A cement that was commonly used on the Fallbrook R. R. locomotive front-ends some years ago to stop all cracks and leaks, was composed of litharge mixed with sufficient boiled linseed oil to make a stiff paste. Into this paste was thoroughly mixed about one-third bulk of old rope cut into short lengths—about one inch—and separated into its constituent fibers. This cement hardens like iron and the rope fibers hold it together while drying and also prevent squeezing out when the front-end casting is bolted to the smokebox. This cement will be found useful in many other places where it will be subjected to heat. M. E. CANEK.

348. FIREPROOFING SOLUTION FOR TOOLMAKERS' APRONS, ETC.

Toolmakers' aprons, factory shades and other inflammable materials may be rendered absolutely fireproof by being treated with the following solution: To ½ pound tungstate of soda add 2 quarts of water, or enough to entirely dissolve it, and bottle up tightly. This stock solution is to be added to sufficient water required to soak the article in the proportion of one-fifth the above solution to the required water. After being soaked, hang the article up to dry. Fireproofing factory shades at windows near gas jets or the cloth aprons worn when working over a fire in hardening and tempering tools, etc., will often save bad fires or serious accidents.

E. W. NORTON.

349. TO GIVE IRON A BLACK COLOR.

To give iron a dead black color, clean all grease and dirt from the metal, and apply the following solution either with a brush or by dipping. Mix together thoroughly 1 part bismuth chloride, 2 parts mercuric bichloride, 1 part copper chloride, 6 parts hydrochloric acid, 5 parts alcohol and 52 parts water. As soon as these parts are thoroughly mixed, the compound is ready for use. After applying the compound, the iron is placed in boiling water and let remain there for one-half hour, the water being kept at the same temperature. Repeat this operation until the color is deep enough, then fix the color by placing the iron for a short time in a bath of boiling oil. After removing, heat in an oven until the surplus oil is all driven off. T. E. O'DONNELL.

Urbana, Ill.

350. ETCHING ON COPPER.

For acid resisting ground use a mixture of 2 ounces white wax to which when melted is added 1 ounce gum mastic in powdered form, a little at a time, until the wax and gum are well mixed. Then, in the same way, add 1 ounce powdered bitumen. When this is thoroughly mixed add to it ½ of its volume of essential oil of lavender. This should be well mixed and allowed to cool. The paste can be applied with a hand roller, and if it is too thick, can be made to flow easier by adding a little more oil. When the paste is applied to the copper plate, expose it to a gentle heat in order to expel the oil of lavender. For a biting or etching acid use a mixture of 5 parts of hydrochloric acid, 1 part of chlorate of potash and 44 parts of water. The water is heated and the potash added. The acid is added first when the potash is fully dissolved. This mixture is used by immersing the whole object to be etched, the object, of course, first being covered on all sides by the acid resisting ground.

Dayton, O. OLIVER E. VORIS.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

C. H. T. Having given a rectangular hopper with the angles a and b of the slope sheets known, produce a general formula in terms of the angles a and b for finding the angle between the intersecting sheets. In other words, give a formula for finding the angle to which the connections between the slope sheets must be bent in order to fit exactly in place.

We have been unable to derive a direct formula for doing this in a single operation. It can easily be done, however, in two operations. Fig. 1 shows three views in third angle projection of an irregular rectangular hopper for which it is desired to find the value of the diedral angle $A\,D$. The important measurement points in this figure are designated by letters. In cases where in a given view these points are one

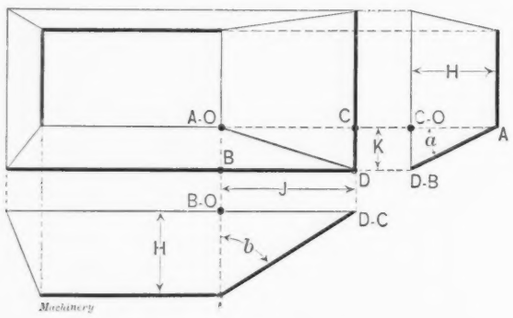


Fig. 1. Diagram of Hopper.

directly behind the other, both letters are used at the same point—as, for instance, at BO in the lower view. O, as may be seen from the other views, being an imaginary point at the intersection of the vertical line AO with the plane of the top of the hopper, while B is a point in the outer rim. We will give the solution in terms of the tangents of angles a and b. It will be readily seen that tangent $a = \frac{K}{H}$ and that tangent $b = \frac{J}{H}$. Fig. 2 is the diagram we will use in deriving our formulas. Similar letters here refer to similar parts of Fig. 1. In addition to the lines of Fig. 1, OD is drawn, and EF at right angles to it. OG is drawn at right angles to AD. Being in plane AOD, OG is likewise at right angles to EF. Lines

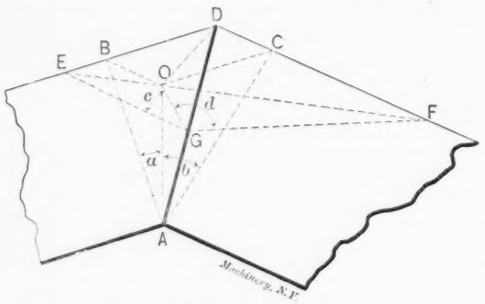


Fig. 2. Solution of Hopper Problem.

EG and FG are also drawn. The angle we are seeking is $\angle\, EGF$. It is composed of $\angle\, EGO$ and $\angle\, OGF$, which we will call c and d respectively. Bearing in mind that Fig. 2 is drawn to an angular projection, so that the angles do not show in their true value, we will proceed to use it in obtaining our formulas.

We see by inspection that, as before stated,

$$\angle\, EGF = \angle\, c + \angle\, d \qquad (1)$$

Further inspection shows that

$$\tan.\ c = \frac{EO}{GO} \qquad (2)$$

Since triangles EOD and OBD are both right angle triangles with a common angle at D, they are similar, therefore

$$\frac{EO}{DO} = \frac{BO}{BD} \qquad (3)$$

Proceeding, and noting that $BD = CO$ we have

$$EO = \frac{DO \times BO}{BD} = \frac{DO \times BO}{CO} \qquad (4)$$

Since triangles OGA and DOA are both right angle triangles with a common angle at A, we may say that

$$\frac{GO}{AG} = \frac{DO}{AO} \qquad (5)$$

Since we will deal here entirely with angles, and not with linear measurements, we will take line AO as our measure, giving it a value of unity. Remembering this we may transform equation 5 as follows:

$$GO = \frac{AG \times DO}{AO} = AG \times DO \qquad (6)$$

Since OG is a perpendicular erected on the hypotenuse of the right angle triangle AOD, and again remembering that $AO = 1$ we have

$$AG \times AD = \overline{AO}^2 = 1 \qquad (7)$$

Since AD is the hypotenuse of the right angle triangle AOD, we have

$$\sqrt{\overline{AO}^2 + \overline{DO}^2} = AD. \qquad (8)$$

Since DO is the diagonal of rectangle $BDCO$ we know that

$$\overline{DO}^2 = \overline{BO}^2 + \overline{CO}^2 \qquad (9)$$

Substituting in equation 8 this value of $\overline{DO}^2$ and replacing $\overline{AO}^2$ with 1, we have

$$AD = \sqrt{1 + \overline{BO}^2 + \overline{CO}^2} \qquad (10)$$

Substituting this value of AD in equation 7 we have

$$AG \times \sqrt{1 + \overline{BO}^2 + \overline{CO}^2} = 1 \qquad (11)$$

Transposing this gives us

$$AG = \frac{1}{\sqrt{1 + \overline{BO}^2 + \overline{CO}^2}} \qquad (12)$$

Substituting this value of AG in equation 6 we have

$$GO = \frac{DO}{\sqrt{1 + \overline{BO}^2 + \overline{CO}^2}} \qquad (13)$$

Now in equation 2 substitute the value of EO as found in equation 4; and of GO as found in equation 13; this gives us

$$\tan c = \frac{DO \times BO}{CO} \times \frac{\sqrt{1 + \overline{BO}^2 + \overline{CO}^2}}{DO} = \frac{BO}{CO}\sqrt{1 + \overline{BO}^2 + \overline{CO}^2} \qquad (14)$$

Remembering that AO is taken as unity, an inspection of Fig. 2 shows us that BO is the tangent of angle a, and that CO is the tangent of angle b. Changing equation 14, then, to agree with this, we have

$$\tan c = \frac{\tan a}{\tan b}\sqrt{1 + \tan^2 a + \tan^2 b} \qquad (15)$$

In a similar way we may prove that

$$\tan d = \frac{\tan b}{\tan a}\sqrt{1 + \tan^2 a + \tan^2 b} \qquad (16)$$

Having found by these formulas $\angle\, c$ and $\angle\, d$, they may be added together as per equation 1 to give the value of the required angle at EGF.

A. W. H. I am building a stationary vertical four-cycle gas engine, 4½ inches bore, 7½ inches stroke. Please state how many cubic inches of clearance space should be allowed for, to get 95 pounds per square inch compression? Of what diameter and weight should the flywheel be for 360 revolutions per minute? How long should the connecting rod be between

centers? What diameter shall I make the exhaust valve opening? What horsepower would the engine develop?

A. A good formula for the compression in a gas engine cylinder is

$$P \times V^{1.3} = \text{constant}$$

In our case, considering the entire volume with the piston at the extreme outer travel as being equal to unity, this becomes

$$P \times V^{1.3} = 1$$

You do not state whether the 95 pounds compression required is absolute or gage pressure. We will consider, however, that it is absolute pressure, which is 15 pounds more than gage pressure; 95 pounds gage pressure, or 110 pounds absolute pressure, would be a rather higher compression than is commonly used on so small an engine. Substituting this value for V in the equation we have

$$95V^{1.3} = 1$$

Solving this equation (you will have to use logarithms to do this) we have

$$V = 0.241$$

which is the percentage of the total volume required by the clearance. The percentage of the total area swept by the piston $= 1.0 - 0.241 = 0.759$. This volume is 119.25 cubic inches according to your figures, so that the total volume of the cylinder equals $119.25 \div 0.759 = 157.11$ cubic inches. Since 119.25 cubic inches of this is swept by the piston the clearance is $157.11 - 119.25 = 37.86$ cubic inches.

With 95 pounds absolute compression, using ordinary coal gas and with a clearance space of the size given, about 70 pounds mean effective pressure can be expected. Using this value for the mean effective pressure in the well-known horsepower formula, we have

$$\frac{PLAN}{33{,}000} = \text{H. P., we have}$$

$$\frac{70 \times \frac{7.5}{12} \times 15.9 \times 175}{33{,}000} = 3.7, \text{ or, say, } 3\tfrac{1}{2} \text{ horsepower.}$$

The connecting rod may be about $2\tfrac{1}{2}\times$ the length of the stroke, or a little more. This brings it about 19 or 20 inches long.

The following formula may be used for the diameter of exhaust valve opening:

$d = 0.00572\, D \sqrt{R\,L}$,

D = diameter of the cylinder in inches,

R = revolution per minute of the crankshaft,

L = length of stroke in inches.

Solving this equation we have $D = 0.00572 \times 4.5 \sqrt{350 \times 7.5} = 1.319$ inch, or say $1\tfrac{3}{8}$ inch diameter for exhaust valve opening. The inlet valve can be slightly smaller, about $1\tfrac{1}{8}$ inch perhaps.

There is no hard and fast rule as to the diameter of the flywheel. This can be made of any convenient size, always remembering, however, that the peripheral velocity should not be more than 3,500 feet per minute. Let us suppose that an outside diameter of 30 inches can be used easily. In order to get the weight of the rim, we will have to find out what percentage of variation in speed we can allow. Since our gas engine receives an impulse every second revolution and sometimes not as often as that (if it is governed on the hit-and-miss principle) it tends to slow down after each charge is exploded, until the next charge is fired. For ordinary work a coefficient of speed variation of 0.05 may be allowed. This would be too high for a dynamo intended for electric lighting and would be very much smaller than would be necessary for a launch engine, but it may be taken as a good average for such work as driving machine tools, pumps, woodworking machinery, etc. This 0.05 variation in this case signifies that the speed may vary between 341 and 359 revolutions. The following formula may be used for finding the weight of the flywheel:

$$W = \frac{\text{I.H.P.} \times 111{,}600{,}000{,}000}{f^2 N^3 E}$$

in which I.H.P. = indicated horsepower,

f = the diameter of the flywheel at the center of gravity of the rim in inches (in this case roughly estimated to be two inches less than the outside diameter),

N = revolutions per minute of the crankshaft,

E = coefficient of unsteadiness permitted.

The indicated horsepower will be slightly greater than the 3.5 brake horsepower we have calculated for the engine. We may call it 4. Our formula now reads

$$W = \frac{4 \times 111{,}600{,}000{,}000}{28^2 \times 350^3 \times 0.05} = 260 \text{ pounds,}$$

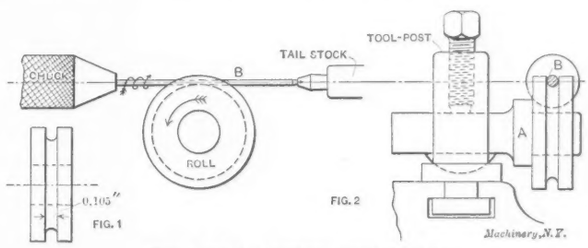
which is the required weight for the rim of the wheel.

For a more extended treatment of the design of gas engines we would refer you to "Gas Engine Handbook," by E. W. Roberts, published by The Gas Engine Publishing Co., Cincinnati, and "Elements of Gas Engine Design," by Sanford A. Moss, published by D. Van Nostrand Co., New York.

Jeweler. I would appreciate some information enabling me to lap jewelers' rolls such as shown in Fig. 1. The groove in these rolls has to be very exact and smooth, as they are used for rolling gold filled stock which cannot be finished afterward except by buffing.

Answered by Frank E. Shailor, Great Barrington, Mass.

A. To satisfactorily lap the slot in a roll such as shown in Fig. 1, I would suggest the following method, fully illustrated in Fig. 2. When machining the slot, care should be exercised in making the slot as smooth as possible before hardening as this will lessen the amount of lapping. After hardening



Figs. 1 and 2. Lapping Jewelers' Rolls.

the roll, take a piece of soft steel rod (in this case 0.105 inch diameter) and secure it in a lathe chuck. The outer end should be pointed to run in a female center. A piece of steel is now made to fit the tool-post of the lathe, and one end is turned to fit the hole in the roll. The roll is placed on the stud *A*, and the carriage of the lathe is moved so that the groove in the roll will come directly under the rod *B*. Smear the rod with flour emery paste, and cause the rod to rotate rapidly by power, and by hand slowly revolve the roll. It will be seen that lapping in this manner will finish the sides of the slot as well as the radius at the bottom. Rig up so that the roll can be moved along on the rod occasionally to compensate for the wear of the rod. When the slot is cut in the soft roll, there will be minute ridges left in the slot, and it is better to have the lap rotate crosswise of the ridges, for if a formed lap is made and caused to rotate in the same line of travel as the slot, the ridges in the roll will spoil the truth of the lap before they are entirely removed from the slot. For high polish after having smoothed the slot, rotate the rod very rapidly using very little emery.

* * *

An advisory committee of the editors of the principal technical papers in New York City has been organized to cooperate with the American Institute of Social Service in the work of protecting life and limb. At the present time the committee consists of representatives of the *Scientific American*, *Iron Age*, *Railway and Locomotive Engineering*, *Automobile*, *Electrical World*, *Street Railway Journal*, *Dry Goods Economist*, *Electrical Age*, MACHINERY, *Railway Gazette*, *Engineering and Mining Journal*, *Engineering News*, *Engineering Magazine*, *American Machinist*, *Power*, *Electro-Chemical and Metallurgical Industry*, *Electrical Record*, *Engineering Record*, *Insurance Engineering*, and *Architectural Record*, all of New York. A meeting of the committee was held at the Aldine Club, April 11, to fix the conditions of competition for the three gold medals that have been offered.

NEW MACHINERY AND TOOLS.

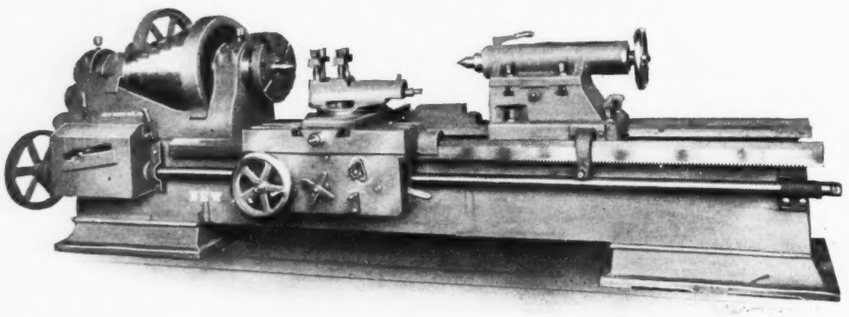
A MONTHLY RECORD OF APPLIANCES FOR THE MACHINE SHOP.

THE NEW HAVEN HEAVY 32-INCH ENGINE LATHE.

The lathe shown in the cut is one of a line of heavy tools which the New Haven Mfg. Co. of New Haven, Conn., has built to meet the demands of modern tool steel, and modern rates of production.

The spindle has a 2 11-16-inch hole through its length, and has a front bearing 5¾ inches in diameter by 9½ inches long. The front and back bearings are split taper boxes of a special bronze metal, and are adjustable by being drawn into the head by means of square threaded nuts at either end. With this style of box it is easy to keep the bearings in proper adjustment without disturbing the alignment of the spindle. The thrust is taken on alternate bronze and tool steel rings hardened and ground. The thrust adjustment is entirely at the back end of the headstock so that the effect of expansion on the length of the spindle is not felt. With a single speed countershaft, ten spindle speeds in geometrical progression are obtained, ranging from 3 to 350 revolutions per minute. When working at its maximum power the 4½-inch belt of the back-geared head machine runs at 86 feet per minute, the back gear ratio being 15 to 1. The lathe may be furnished, if desired, in the triple geared design, in which case the maximum speed of the 5½-inch belt used is 240 feet per minute.

The feed changes are obtained through a rapid-change gear device of the design illustrated and described in our issue of August, 1904. The various levers are so interlocked as to prevent all possibility of damage from careless handling of the device. A special feature of this gear box is the provision made for connecting the lead screw directly to the driving gear shaft by a positive clutch. When this is done, ordinary change gears may be used in the usual manner for cutting special threads, as if there were no change gear device incorporated in the machine. In addition to the usual range of threads, spirals of from one turn in 1 inch to one turn in 12 inches may be cut by throwing in the back gears, the threading mechanism being so arranged that it can be connected under these conditions to the back gears instead of to the spindle, if desired.



New Haven 32-inch Engine Lathe.

The apron is of the double-wall, box form, bevel gear driven from the splined lead screw, and powerfully geared throughout. The cross and longitudinal feeds interlock with the lead screw nut in such a way as to prevent one of them from being thrown in simultaneously with the others. Both feeds are controlled by a friction drive, and the hand wheel pinion may be disengaged when cutting threads. A rigid and compact taper attachment is fastened to the rear of the carriage in such a fashion as to control the compound rest without interfering with the use of the cross feed screw for adjusting the tool. It will turn tapers up to 4 inches per foot and 24 inches long, and is graduated both in inches per foot and in degrees. The compound rest has a power feed in all directions, and is graduated in degrees. The cross feed screws are also graduated. The tailstock has a pawl engaging a rack cast solid in the bed, which makes slipping under heavy duty impossible. This 32-inch swing lathe can be furnished with beds of even lengths from 14 to 36 feet.

SPRING COLLET ATTACHMENT FOR LATHE.

The Adjustable Collet Co. is a recently organized firm located at 224 High Ave., Cleveland. It is placing on the market a convenient attachment for giving to an ordinary lathe some of the advantages of the screw machine—so far, at least, as the work holding features are concerned. The device is illustrated in the three accompanying halftones.

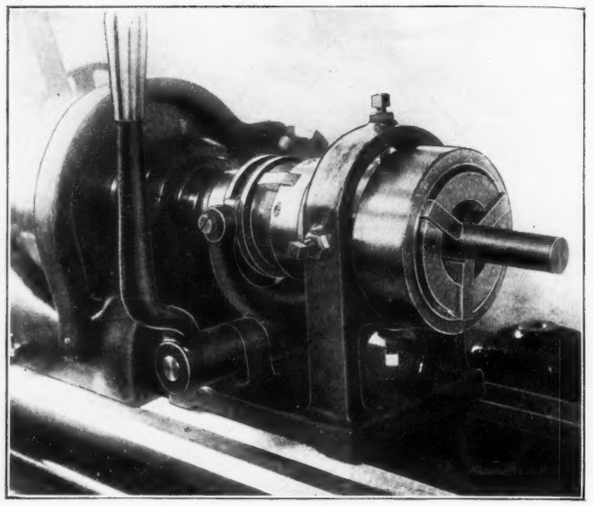


Fig. 1. Automatic Collet Attachment Operating on Bar Stock.

The rear end of the spindle of the device is screwed to the threaded nose of the lathe spindle. The front end is carried in a bronze taper bearing, adjustably supported by the casting which forms the frame of the attachment. The adjustment allows both vertical and horizontal shifting of the bushing by means of setscrews and check nuts, to bring the outer end of the supplementary work spindle accurately to alignment with the axis of the lathe.

In the form of chuck shown in Fig. 1, three jaws are used to grasp the stock. These jaws move radially with a direct thrust, and bear on stock of different diameter for their full length, gripping all sizes in fractions within their capacity. In this design the draw-in principle is used. The jaws are

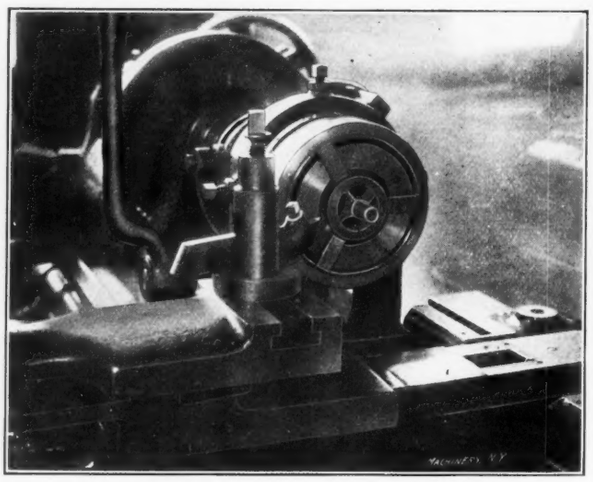


Fig. 2. Attachment arranged with Step Jaws for holding Castings, Disks, Etc.

closed by the action of a sliding cone of the usual type at the rear of the supplementary spindle. This cone, actuated by the hand lever shown, opens the chuck levers, draws the chuck jaws into the taper, and thus closes them on the stock. Adjustment for size is obtained in the usual manner by screwing in or out the threaded bushing which backs the chuck levers.

In Fig. 2 the attachment is shown adjusted for large diameter, and a casting is shown in place in the jaws. Various forms of these jaws may be provided for work of different

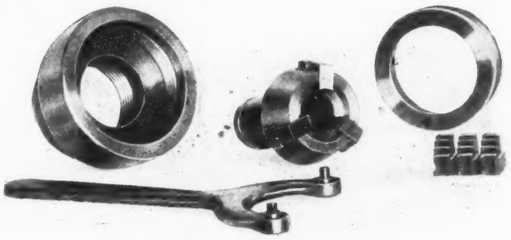


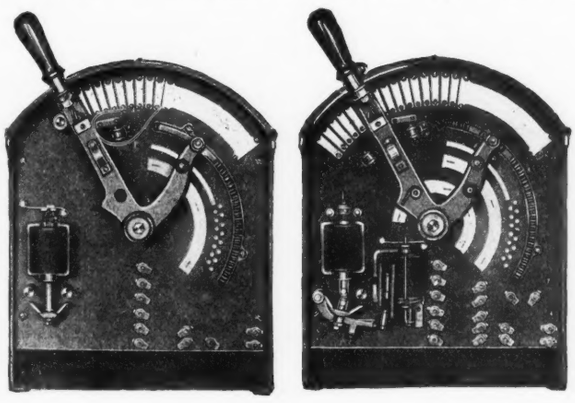
Fig. 3. Details of Spring Collet Attachment.

kinds, the stepped form being a very useful one for castings and disks. This chuck may also be made in the four-jawed form, when it is able to handle square stock. A further variation of the device is shown in Fig. 3, where the "push" form of action has been used. Plain jaws of large capacity are shown in place in the collet while stepped jaws are shown disassembled.

This attachment is made for any size or make of Fox, speed, or engine lathe, or for plain head turret machines—in a word, for any lathe not having an automatic chuck. The portable base of the attachment allows a sufficient vertical adjustment to adapt the attachment to lathes of varying makes and sizes. The attachment does away with the necessity for separate collets for each size of bar stock, or for false bushings. They are made, as before mentioned, in push or draw form, either with three or four jaws, the four-jaw collet being used on square or octagon stock and the three-jaw for round or hexagonal stock.

IMPROVED CUTLER-HAMMER CONTROLLER FOR MACHINE TOOLS.

The Cutler-Hammer Mfg. Co. of Milwaukee has recently placed on the market a new line of printing press and machine tool controllers. These controllers are of the well-known Carpenter type, and embody the distinctive features of this class of Cutler-Hammer apparatus. The essential difference between the new controllers and the older type is that the



Non-reversible and Reversible Cutler-Hammer Controllers for Machine Tools.

former provide for a greater number of field speeds than the latter.

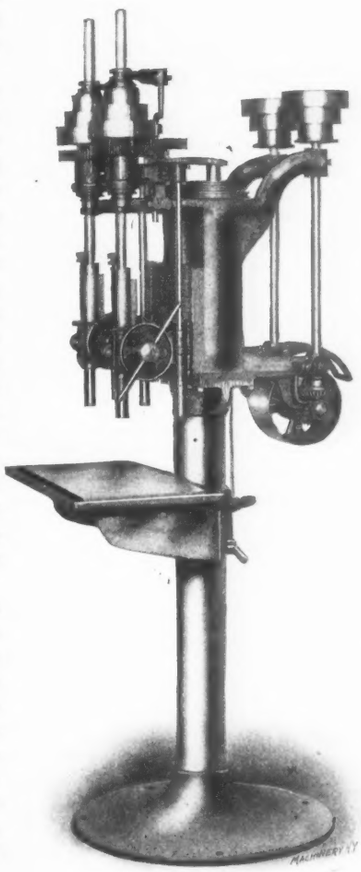
At the time the first "Carpenter" printing press and machine tool controllers were placed on the market it was the accepted practice to obtain the major portion of speed variation by means of armature resistance, the increase in speed secured by means of field control seldom exceeding 15 per cent. Of late, however, variable speed motors, so designed as to permit of their speed being increased as much as 400 per cent by field control, have come into use, and the present line of controllers has been designed to meet this new condition in printing press and machine tool work.

Like the older type of apparatus, the new line of controllers is provided with an auxiliary breaking device equipped with a powerful magnetic blow-out. In opening the circuit by moving the lever to the "off" position, the break does not occur on the contacts, but on an auxiliary device located just below the contact segments. This prevents arcing on the contacts. The contact segments themselves are of hard-drawn copper and are separately renewable.

The controllers are equipped with cast iron covers which completely enclose all of the apparatus except the handle of the operating lever. All contact parts are removable from the slate front without disturbing the interior connections, and all terminals are labeled with brass tags, insuring proper wiring.

In this new line of controllers the speed regulation is effected by means of both armature and field resistance, the armature resistance being furnished separately, though it is possible to mount it with the front if desired. The field resistance is, in all cases, attached directly to the front of the controller, and provision is made for positively holding the lever on any desired contact.

Six distinct pieces of apparatus are comprised in this latest line of printing press and machine tool controllers—three non-reversible and three reversible. In each class the controller may be had with underload release only, with underload and overload release, and with underload, overload and push-button release and dynamic brake.



Reed Two-spindle Drill.

The new apparatus is described in Cutler-Hammer bulletins Nos. 81½, 82½, 83½, 84½, 85½ and 86½.

REED TWO-SPINDLE DRILL.

The Francis Reed Co. of Worcester, Mass., is building the new drill press shown in the accompanying half-tone. The machine is designed to fill in the gap between the sensitive drill press and the lighter styles of back gear drill, and at the same time retain as many of the valuable features of both as possible.

The independent style of drive used by the builders on their regular line of drills is retained. The countershaft is combined with the machine, and drives the vertical back shafts through bevel gears, one of the pair being rawhide, which makes it a very quiet running machine. The spindles are driven by three-step cones, using open belts 1½ inch wide. The spindles have a 1-inch bearing through the quill, which will allow a feed of 6 inches. This, added to the 4-inch adjustment permitted by the sliding bracket, gives a movement of over 10 inches without moving the table. When the back gears are thrown in, the drive gives a reduction of about

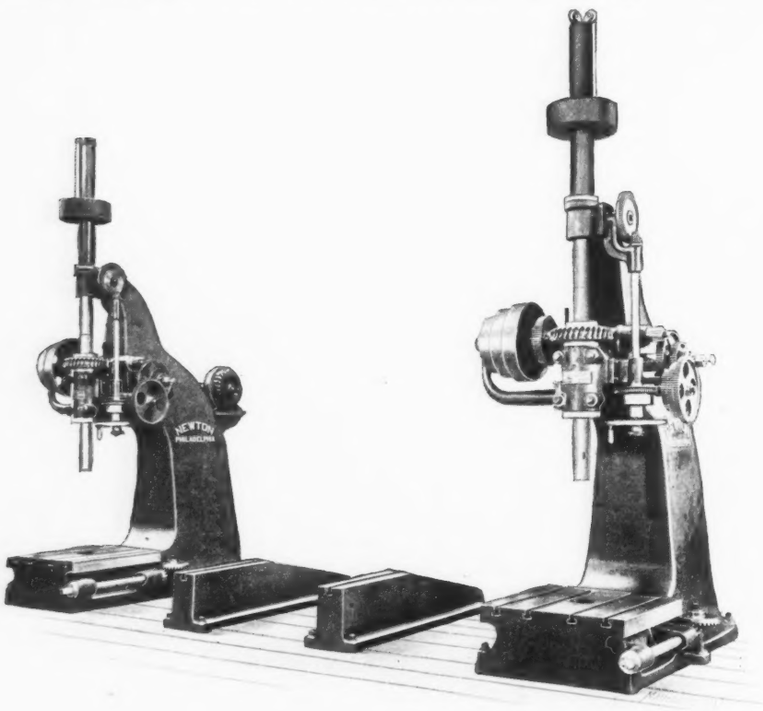
7 to 1, and is powerful enough to drill holes up to 1 7-16 inch in diameter. Without the back gears, the machine is capable of doing the delicate work of a sensitive drill. The back gears are entirely disengaged when thrown out, and are easily brought into gear and locked in position by the movement of a single lever. They are very easily handled, change from a light sensitive drill to a back-geared machine being made in a moment's time. Since the spindles are independent of each other, one may be used with the back gears and the other without, when the nature of the work demands it.

Special attention is called to the feed, which may be furnished with this machine when desired. It has three speeds, giving movements of 0.009, 0.011, and 0.014 inch, respectively, per turn of the spindle. With the countershaft running at 450 revolutions per minute, the mechanism will feed 10 inches per minute with the speed and feed in their fastest positions. The feed is independent for each spindle and derives its power from that spindle, so that the movement will stop if the driving belt for a spindle slips or breaks, thus saving breakage of drills.

The table will move up or down or swing clear around if necessary. It is counterweighted, so that the workman may easily adjust it if it is not too heavily loaded. The drill has a swing of 16 inches.

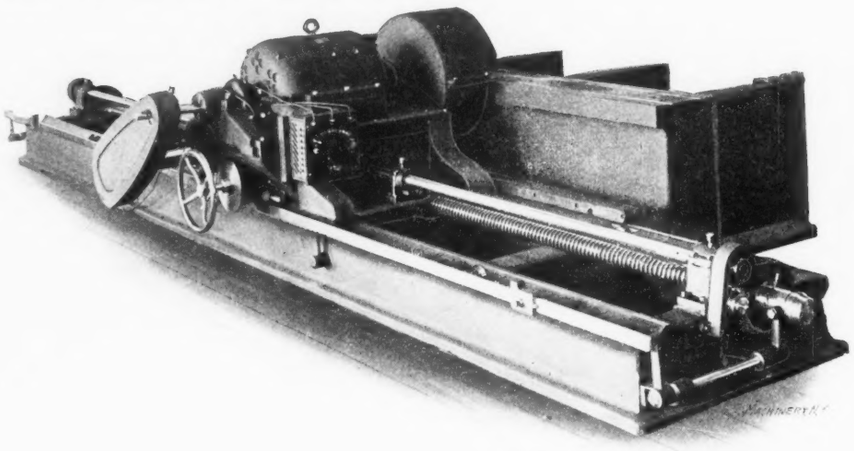
NEWTON CHORD BORING MACHINE.

In boring chords and other members of bridge and structural steel work, the vertical position of the boring bar is the most suitable arrangement. The work being often of considerable size and weight, it is advisable, as well, to bore the holes at each end at the same time whenever possible. The machine shown in the accompanying half-tone, built by the Newton Machine Tool Works, Inc., Philadelphia, Pa., is built to meet the requirements of work of this kind.



Newton Chord Boring Machine.

The machine is composed, as shown, of two uprights and two central supporting pieces. These are intended to be fitted to a long base made up of I-beams, on which the uprights will be adjustable to give different center distances, the adjustment being made by a vertical pinion through bevel gears, as shown. Besides the small intermediate supports for the work, the machine may be made with adjustable work tables if desired. A hole is bored in the work table for a lower support to the boring bar.



Motor-driven Edge Grinder.

The spindle is 4 inches in diameter, and has a 32-inch continuous automatic feed, with four geared changes and a rapid hand adjustment. The spindle is driven by a phosphor bronze worm-wheel through back gears, and in the arrangement shown in the cut an alternating-current motor is used, which is connected to the driving shaft by a pair of cones and a belt. The distance from the center of the spindle to the upright is 30 inches. The distance from the end of the spindle to the work table is 42 inches. The work table is 36 inches square.

MOTOR-DRIVEN EDGE GRINDER.

The illustration shows a large motor-driven edge grinder, adapted to handle work up to 160 inches long. It was designed primarily to grind the edges of heavy laminated safe plates, but is well adapted to do other work of this kind.

The wheel carriage slides on one V-way, 5 inches wide, and one flat way, 6 inches wide, with a bearing on the ways, 60 inches long. The working part of the platen is 15 inches by 160 inches, but five projections 30 inches long each are provided to support extra wide plates, etc. The machine is driven by a 12½ H.P. direct current Robbins & Myers motor, which operates both the grinding wheel and the travel of the carriage.

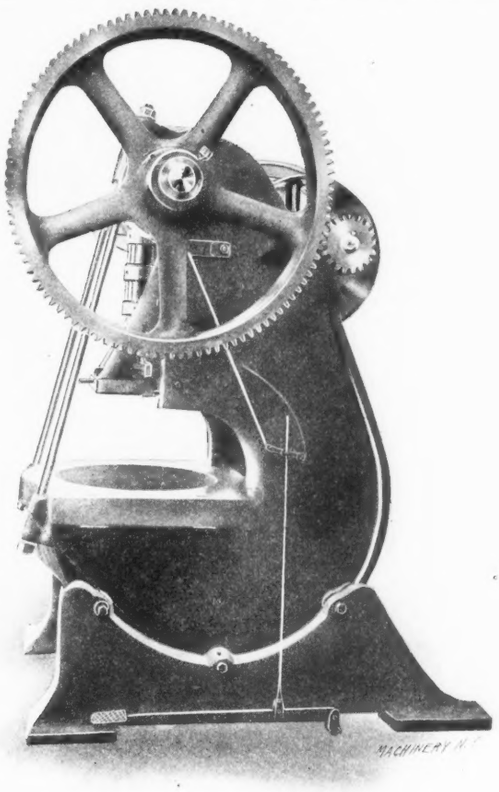
The carriage is driven from one end of the motor spindle by means of a Morse silent chain, which connects it to a splined shaft by bevel gears, which, in turn, alternately engage with a 3½-inch leadscrew (1-inch pitch) by means of clutches. The emery wheel cylinder is 20 inches diameter, mounted in a safety chuck, and can be fed to the work from 0.001 to 1-16 inch per stroke, either automatically or by handwheel, as desired. The emery wheel can easily be removed when required by running the carriage to the extreme end of the stroke, which allows a new emery wheel to be placed in the chuck without interfering with any part of the machine.

The machine occupies a floor space 10 feet 7 inches wide by

24 feet long, and weighs, approximately, 23,000 pounds. It was designed and built by The Safety Emery Wheel Co., Springfield, Ohio.

A LARGE TILTING PRESS.

The cut shows a large tilting or "tip-back" press recently built by the Perkins Machine Co. of Warren, Mass. Its builders believe it is one of the largest ever made. It weighs approximately 18,000 pounds, and may be swung backward as far as is necessary to make the punchings fall from the dies



Perkins Large Tilting Press.

by gravity. The main gear is 60 inches in diameter and weighs 1,950 pounds. The crankshaft is 6 inches in diameter at the bearings. The opening in the bed is 33 inches in diameter. A positive knock-out is applied to the plunger, being operated by the cross bar shown, which strikes adjustable stop screws on the face of the ram guide at either side of the machine.

THE BRICKNER TILTING VISE.

The Sterling Emery Wheel Mfg. Co., Tiffin, Ohio, is building the Brickner tilting vise, a tool intended for general machine shop use and adapted for work to be done in the drill press, milling machine, shaper, etc. The vise can be adjusted to any angle, from the horizontal to the perpendicular, without having the clamping mechanism interfere with the work in any way, or without making it necessary to disturb the adjustment to open and close the jaws of the vise. The jaws open 6 inches, are 2 inches high, and 5 inches wide. An 8-inch crank is furnished with each vise. The weight is about 40 pounds.

NEW DOUBLE DISK GRINDER.

Chas. H. Besly & Co., 15-17-19-21 S. Clinton St., Chicago, have recently designed a double disk grinder which is an adaptation of their regular single-head spiral disk machine. The use of two heads makes it possible to finish both sides of a piece of work at the same time, giving it smooth and parallel surface. The work is supported by a holder which can be swung in between the two disks. The body of the holder is a casting provided with a projecting handle, and clamped to a swinging bar which has a fine endwise adjustment for centering the work between the wheels. The heads are mounted on V's planed on the bed casting, and clamped in position in the same way as the tailstock of a lathe. Both spindles have about 1 inch longitudinal feed in the heads to bring the disk wheels in contact with the work. This movement is actuated either by hand lever or by foot lever, as may be desired.

A feature of this and all other double disk grinding machines built by this firm is the sliding bearing bushings which encase the spindles, and protect the bearings from emery and dust. The spindles have only about 1 inch sliding movement, so the disk wheel is always near to and readily supported by the main head casting. The spindles are 1¾ inch in diameter with cast iron split bearings, adjustable for wear. The end thrust of the spindle is taken between the pulley and the back bearing bushing on hardened and ground thrust collars of large area. The spindle pulleys are 7½ inches in diameter for a 6-inch belt. The disk wheels regularly furnished are 18 inches in diameter by ⅝ inch thick, but the machine will swing wheels 22 inches in diameter. The maximum opening between the wheels is 20 inches. The machine, complete with countershaft, press, etc., weighs about 3,500 pounds.

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INDUSTRIAL NOTES FROM EUROPE.

BRITISH ENGINEERING TOPICS.

General activity still prevails in British Industrial circles. So much capital is called for in connection with business promotions and extensions that government gilt-edged securities are quoted at the lowest prices ever recorded. Much better financial returns are obtainable from commercial investments, and the spectacle is thus presented of absolutely safe securities offered at little more than 75 per cent of their par value. This point is merely mentioned as an illustration of the complicated factors which—often unsuspected by those affected—conduce to the prosperity and well-being of those associated, as manufacturers, officials, and employes, with industrial enterprises.

A feeling of unrest pervades the engineering trade in several parts of the country owing to the demands of the workmen for increased wages. There appears a disposition on the part of employers to refuse these applications, and prolonged negotiations on the matter will probably ensue.

The Lancashire cotton and engineering trades are offering strong opposition to a private bill introduced into the Houses of Parliament which proposes to make the use of metric weights and measures compulsory. In the cotton trade it is feared that any disturbance of present customs would involve an enormous outlay in changing parts of machinery, would be likely to arouse unjust suspicions of unfair dealing amongst Eastern customers, and would upset standard wages lists which have taken fifty years to build up. The engineering and cotton machine building concerns were equally emphatic in their statements during a joint representative deputation of employers and workpeople which recently waited on the president of the Board of Trade.

A feature of the last few years is the extent to which merchants handling American machine tools have been compelled to turn to British sources for supplies, in consequence, partly, of the enormous American home demand causing restricted deliveries over here. More than one of these houses either themselves build tools or control works specializing on their behalf. Another cause of this tendency is the greater demand for those British tools which have proved best adapted to insular requirements. Continental machine tools, etc., are now being actively pushed from their new London headquarters, by Schuchardt & Schütte of Berlin, Germany.

Any broad survey of British industries during the last number of years must include the developments due to the employment of capital accumulated by workmen from the profits of cooperative trading. From the smallest beginnings in the grocery, etc., line by local societies run by artisans in their spare time, an enormous business has been built up. The smaller associations, after dividing the profits quarterly, formed reserve funds and, in time, in order profitably to employ these funds, federated as the "C. W. S." or Cooperative

Wholesale Society, which is a society whose shareholders are smaller societies, and which, in addition to purchasing and distributing foodstuffs and other household necessities on a large scale, has also embarked on productive enterprises, the profits from all departments being divided amongst its constituents. Among the industries now carried on by this unique combination may be mentioned corn milling, boot and shoe manufacture, soap, its residual and allied products, jam, biscuits, furniture, clothing, tobacco, farm produce, steamship owning and running, etc. Separate organizations—which act together on matters touching their interests—exist in England and Scotland. From the last half-yearly report of the English section, it would appear that the turnover was $112,500,000, an increase of over $8,500,000 on the previous half year. The deposits and withdrawals in the banking department totalled $275,000,000, an increase of $18,500,000. The societies' own products amounted to over $22,500,000, an increase of $4,750,000. Up to now, no engineering department has been attempted, the industries touched being those capable of being worked on repetitive lines without much originality being required. It must, however, be admitted that the best machinery obtainable has generally been employed.

Some perturbation has been caused in Staffordshire by the action of German firms who have induced a number of expert chain makers to leave Cradley Heath, the home of this industry, in order to train German workmen in the manufacture of heavy anchor chains, etc., hitherto practically a monopoly of the district. It is not yet certain whether, by this action, a permanent displacement of a portion of this important trade will result. The migration of the expert workmen has been strongly opposed by both employers and the general body of workmen. The making of small chains is carried on in this district in many cases under conditions which disgrace civilization, women and girls forging the chains at their own homes for miserable wages. A certain amount of organization of workers has, however, taken place recently, with the result of wage advances of 10 to 20 per cent with some prospects of general improvement in environment. Men employed in the heavier branches are in a position to earn good wages in many cases, though from what I have seen, few of them ever work on Mondays, and in many shops the men employ a messenger solely to bring in beer for consumption during working hours. I have been informed by a prominent manufacturer that one special reason for the strong position occupied by Cradley Heath in the chain-making industry is the quality of coke or breeze employed. This breeze is made from coal mined locally, and the seams containing it are practically restricted within a very small radius of the town.

Certain machine shop accessories in the way of chucks, vises, etc., have been very successfully specialized in by Charles Taylor, of Birmingham, who manufactures large numbers of self-centering chucks which combine powerful grip with great durability. His machine vise, which gives quick adjusting facilities and good grip, also draws the work down onto the packings. It has been extensively produced—and imitated. His concern is broad enough to recognize the good points of American chucks for many services, and merchants them with his own lines. A comparatively recent product of this house is the "Instanter" bench vise, arranged for rapid manipulation (see MACHINERY, October, 1904). Predecessors and contemporaries in this field who have made capital records and experience constant expansion include Messrs. Parkinson, of Shipley, and Enturstie & Kenyon, of Accrington. Other makers, who are paying attention to the matter of independent four-jaw chucks include Dean, Smith & Grace, Ltd., Keighly, who, by the way, have recently considerably extended, and Lang, of Johnstone, N. B. The increasing use of high-speed tool steel, under favorable conditions, is mentioned by one of these firms as leading up to the special treatment of chucking facilities, and the other concern gives as a cause for success the greater energy infused into their work by men working on modern premium and bonus systems.

Metal-sawing machinery has also a number of exponents who each contrive to bring into prominence various meritorious features. Isaac Hill & Co., Derby, pioneered the "flush side" circular saw which allows of cutting "gates" or "risers" from large steel castings. Quite a number of makers exploit other variants of the circular saw, and in the band-saw line may be mentioned Noble & Lund, Newcastle; B. & S. Massey, Manchester, and Clifton & Waddel, Johnstone, N. B. E. G. Herbert, Ltd., Manchester, has considerably enlarged the scope of the power hack-saw by the introduction of the "Eccentric" pattern, which deals rapidly with sections up to 18 x 30 inches The firm also makes hack-saws for handling materials up to 4 inches diameter, entirely automatically, the cycle of operations continuing automatically until the entire bar of material is cut up into uniform lengths, when a bell rings to warn the attendant. John Holroyd & Co., Ltd., make a line of large hack-saws in which the work slowly revolves while being cut, with consequent increased production. A Midland firm which prefers to remain anonymous to a large extent, its product being factored rather than sold direct to users, is producing a hack-saw for work up to 4½ inches diameter, in which straight cutting has been the principal object aimed at, this being attained by means of a quadrant bracket which steadies the saw frame throughout its movements through the piece, and which admits of any side play being taken up for an indefinite period. JAMES VOSE.

Manchester, March 18, 1907.

MISCELLANEOUS FOREIGN NOTES.

POWER TRANSMISSION ON LARGE SCALE IN FRANCE.—A 1,100 foot head is being utilized in a new hydro-electric plant on the Siagne River, a stream of the Maritime Alps in Southern France. A 30,000-volt transmission line is now in the course of construction to Marseilles. The length of this line will be nearly 100 miles.

THE ERNST SCHIESS MACHINE TOOL WORKS AND FOUNDRY in Düsseldorf, Germany, has been turned over to a company under the name of Ernst Schiess Werkzeugmaschinenfabrik A. G. The company is to continue the building of machine tools as well as buying and selling machinery of all kinds. The capitalization is 3,300,000 marks.

INTERNATIONAL EXPOSITION IN BELGIUM.—A world's fair and international industrial exhibition will, according to a statement made upon the authority of the Belgian government, take place at Brussels, Belgium, in 1910. The exhibition will be held under the auspices of the Belgian government. This exposition is expected to be the largest in Europe since the world's fair in Paris, 1900.

NEW FRENCH MACHINE TOOL COMPANY.—A number of French business men, actively engaged in the automobile industry, have formed a company with a capital of $1,200,000 for the manufacture of machine tools, particularly such as are required for automobile construction. It is not as yet definitely settled upon where the works will be located, but it is likely that they will be erected in Puteaux, near Paris.

AUTOMOBILE SERVICE IN AUSTRIA.—The reports from Europe indicate that the motor car has been put to commercial use to a far greater extent there than it has in this country, where it has been mainly devoted to pleasure or luxury. The Austrian government is now intending to provide all districts, where railroads would not pay, with automobile service. This movement has been received very favorably by the communities concerned. Only in a few instances opposition has been met with because of the fear that the automobile service would retard the construction of railroads.

THE EFFECT OF THE TARIFF ON GERMAN MACHINE INDUSTRY.—The U. S. Consul-General at Frankfort, Germany, reports that the German machine tool builders are not particularly pleased with the new German tariff on machinery. The increase in the tariff duties handicaps not only the importation of necessary machine tools, but on account of the accompanying treaties with foreign countries, handicaps the exportation as well. Germany with its hitherto low tariff on machinery has in a few years built up an enormous trade with foreign countries, importing as well as exporting during 1906 nearly twice as much as it did five years ago. It is doubtful whether there will be very many interests in Germany that will benefit from the curtailing of the country's trade.

THE BICYCLE BUSINESS IN GREAT BRITAIN DURING YEAR 1906.—The London *Statist*, in reviewing the cycle industry in the United Kingdom in a recent issue, says: Speaking generally, the year just ended has proved one of the most satisfactory that the trade has yet had—the works have been busier and the output greater than at any other period. On the other hand, the larger output has been accompanied by a smaller margin of profit than was the case when there was a "boom" in the industry in 1897. So that with a broader basis the trade is in a healthier condition.

THE FINANCIAL ASPECT OF THE MACHINE BUILDING BUSINESS IN GERMANY.—The yearly statements of German machine firms show that from a financial point of view the past year has been one of great business prosperity, and not only has the production been greater than ever before, but the dividends paid on the capital invested are so high as to indicate a far more than normal prosperity. Out of nine firms taken at random, as reported by the *Zeitschrift für Werkzeugmaschinen und Werkzeuge*, none paid less than 7½ per cent, one paid 9 per cent, four paid 10 per cent, one 12 per cent, one 14, and one 34 per cent dividend. In general it seems that the machine building firms in Germany pay a very high interest on the capital invested, as the dividends in the previous year were in most cases the same or only 1 per cent less than those reported for 1906. On the other hand at the meeting of the Trade Guild held in Berlin in March, in reviewing the past year, it was reported that although the year had been one of great gross profits, a number of the works at the close of the year showed very meagre profits. This is attributed to the great increase in price of raw materials and half finished products. The Trade Guild, however, appears to be a combination of the kind which we generally class as trusts, and the failure to realize great profits may have been due to its trust methods which do not work well in competitive business. It was intimated that a great deal of the difficulties encountered was on account of the competition of works not affiliated or organized for syndicate working. These works, as far as we understand, are the ones that have shown very high profits. As the machinery trade is a purely competitive business, one feels obliged to admit that it is gratifying to see that the smaller competing firms are able to hold their own against the combination referred to.

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PERSONAL.

Edgar Bloxham, Paris, France, importer of machinery and tools, visited the United States in March and April in the interest of his business.

Fred A. Geier has been made president and general manager of the Bickford Drill & Tool Co., Cincinnati, Ohio. F. M. Huschart, formerly of the Marshall & Huschart Machinery Co., Chicago, is assistant to the president and is managing the Bickford plant.

William J. Kaup, the head of the machine shops of Pratt Institute, Brooklyn, N. Y., will be granted leave of absence during the academic year of 1907-08. In view of this fact, the associated evening machine classes met at the Institute club on the evening of March 20 and presented to Mr. Kaup a handsome gold watch. The following paragraph expresses the spirit of the classes in making the presentation, and is engraved in the case:

"Presented to Mr. William J. Kaup by the Associated Evening Machine Classes of Pratt Institute as a token of our appreciation of his untiring zeal in our behalf as students and men. March 22, 1907."

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FRESH FROM THE PRESS.

THE THETA-PHI DIAGRAMS. By Henry A. Golding. 126 pages, 5 x 7 inches. 48 cuts and diagrams. Second edition. Published by the Technical Publishing Co., Ltd., Manchester, England, and D. Van Nostrand Co., New York. Price, $1.25.

This work endeavors to show the use of the temperature-entropy diagrams and the various methods of drawing them for different heat motors. Little change has been made in the second edition. To give an idea of the character of the work the headings of the chapters may be enumerated. Entropy; Entropy of Water and Steam; Conversion of Indicator Diagram to Entropy Diagram; Heat Losses; Application to the Gas Engine; Application to Oil and Air Engines.

LUBRICATION AND LUBRICANTS. By Leonard Archbutt and R. M. Deeley. 528 pages, 5½ x 8½ inches. 157 cuts. Published by Chas. Griffin & Co., Ltd., London, and J. B. Lippincott Co., Philadelphia. Price, $6.00.

The book in review is of the second edition, the first edition having been published in 1899. The work is an excellent companion book to our American book, "Friction and Lost Work in Machinery and Mill Work," by Robert H. Thurston. It contains a much more thorough treatment of lubricants, and describes a large variety of apparatus. The second edition has been thoroughly revised and considerable new matter added, including a brief account of Lasche's experiments. The book can be heartily recommended to those interested in the subject of friction and lubrication, tests of lubricants, and the general subject of lubrication of machinery.

MODERN STEAM ENGINEERING. By Gardner D. Hiscox. Electrical section by Newton Harrison. 487 pages, 6 x 9 inches. 405 cuts. Published by Norman W. Henley & Son, New York. Price, $3.00.

The opening chapter is devoted to the history of the steam engine, following which steam and its properties are discussed. Chapter III is on the generation of steam furnaces and their adjuncts, the various grate constructions of furnaces, etc. Then are taken up in order types of boilers, chimneys, feed-water heaters, motors, generators and steam pumps, boiler incrustation, flow of steam through orifices, superheated steam, adiabatic expansion of steam, the steam engine indicator, steam engine proportions, the slide valve and valve gear. Corliss engines, compound engines, triple and quadruple expansion steam engines, the steam turbine, mechanical refrigeration, the elevator, the cost of power, the engineer and his duties. The electrical section by Mr. Harrison treats briefly of the dynamo and its regulation and testing; motors; the switchboard and storage batteries; lighting and lamps. From the foregoing it will be seen that the book is of a very comprehensive character. It brings together in one volume a large mass of information valuable to the working engineer. The addition of the electrical section is an excellent feature, for there are few engineers nowadays who do not require considerable practical knowledge of electrical apparatus. A feature that will be popular is the questions and answers to the chapters in the electrical section. The book is well printed and well bound and excellently illustrated. Numerous tables are included, there being a total of over 40 in the work.

BULLETIN NO. 9. AN EXTENSION OF THE DEWEY DECIMAL SYSTEM OF CLASSIFICATION APPLIED TO THE ENGINEERING INDUSTRIES. By L. P. Breckenridge and G. A. Goodenough. 72 pages, 6 x 9 inches. Published by the University of Illinois, Urbana, Ill.

The Dewey decimal system of classification is well-known to librarians and others who have to do with the arranging and cataloguing of books, pamphlets, drawings, information, etc. It is the most simple and comprehensive scheme of the kind that has ever been devised. Considerable use of it has been made in engineering and industrial work. It has been adapted, for instance, to the filing of technical data, catalogues, reports, card systems, drawings, etc., and it has been found equally useful for manufacturing and business concerns. As originally developed the classification was not minute enough for technical and industrial uses of this kind. This pamphlet is the result of some years of study and experience in the work of expanding the classification to meet the most severe requirements of modern conditions. The first edition was a small pamphlet of six pages. The demand for it was so great that within a year a second edition was printed and this has been followed by third and fourth editions. In each successive edition the expansion has been carried somewhat further, in the third was incorporated with slight modifications the expansion for railroads and railroad engineering adopted by the International Railway Congress. In this present issue are included the expansions already worked out, and the expansion for electrical engineering made by Mr. J. M. Bryant of the electrical engineering department of the University of Illinois, together with more or less complete extension for other branches of engineering. The whole, it is hoped, will be a self-contained classification which will cover with comparative completeness the entire ground of engineering industry. So far as we know there has been no other expansion of this kind worked out, and as this seems to have been made with great care, we see no reason why it should not be adopted by everyone who has anything in the way of books, pamphlets or data of an engineering nature which he desires to file and keep track of. No one who has anything of this kind to do should be ignorant of the merits of the Dewey decimal system. This pamphlet, combined with a bulletin of the Library Bureau of Boston and New York entitled "Decimal Classification and Relative Index," will give anyone a good working knowledge of the system.

NEW TRADE LITERATURE.

WESTERN ELECTRIC CO., Chicago, Ill. Folder calling attention to the Western Electric motors for ventilating fans.

LINK-BELT CO., Philadelphia, Pa. Revised price list of sprocket and traction wheels.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Boston, Mass., has issued a booklet outlining its summer courses for 1907.

GISHOLT MACHINE CO., 1316 Washington Ave., Madison, Wis. Leaflet describing a method of finishing flywheels in one operation.

THE UNIVERSITY OF PENNSYLVANIA, Philadelphia, Pa., has issued a book descriptive of the Engineering Building recently erected there.

IRLAND PIPE WRENCH CO., 15 Court Square, Boston, Mass. Leaflet descriptive of the Irland automatic wrench.

INDEPENDENT PNEUMATIC TOOL CO., First National Bank Bldg., Chicago, Ill. Circular E, illustrating types of Thor air hammers and drills.

B. F. STURTEVANT CO., Hyde Park, Mass. Bulletin 143 on generating sets with horizontal engines, describing and illustrating these sets as used with class H C 1 engines.

THE HEALD MACHINE CO., Station D-2, Worcester, Mass. Circular illustrating the Heald ring and surface grinder and giving a list of some of the customers using this machine.

DODGE & DAY, Drexel Bldg., Philadelphia, Pa. Illustrated pamphlet No. 16 entitled Methods and Work of an Engineering Organization, being one of a series concerning recent work done by this company.

KEUFFEL & ESSER CO., 127 Fulton St., New York. Recent circulars describing automatic print hanger, folding rules, and pocket calculator.

ARTHUR M. DUFF, publisher, 52 Canton St., Boston, Mass. Leaflet descriptive of wage calculator books designed to save all figuring and errors in the computation of wages.

THE OWEN MACHINE TOOL CO., Springfield, O. Circulars illustrating and giving specifications for No. 2A universal miller, No. 2B plain miller, No. 3A universal miller and No. 3B plain miller.

THE HIGH DUTY SAW & TOOL CO., Eddystone, Pa. Illustrated catalogue descriptive of its line of high duty sawing machines and Tindel high-speed steel saw blades.

J. H. WAGENHORST & CO., Youngstown, O. New circular illustrating their electric blueprint machines. A list of the users of this machine and references from various companies are included.

ARMSTRONG BROS. TOOL CO., 113 N. Francisco Ave., Chicago, Ill. Catalogue No. 14 illustrating and giving tables of specifications for Armstrong tool-holders.

ROTARY FILE & MACHINE CO., INC., 589 Kent Ave., Brooklyn, N. Y. Booklet illustrating and describing band-saw machines, sharpeners, setters, blades, guides and brazers.

THE ASHCROFT MFG. CO., 85 Liberty St., New York City. Catalogue for 1907 describing various gages, indicators, pipe stocks and dies, ratchets and other instruments and tools manufactured by this company.

THE KNECHT BROS. CO., 819 Wade St., Cincinnati, O. Circular setting forth the advantages claimed for the Knecht friction sensitive drill. Those interested in this drill may obtain further particulars by sending the post card attached to the circular to the company.

GOLDSCHMIDT-THERMIT CO., 90 West St., New York City. Description of the Thermit welding process and of repair jobs made by this process. Special attention is called to its application to the transportation companies.

BALLINGER & PERROT, Philadelphia, Pa. Pamphlet on concrete industrial plants, being illustrated with examples of reinforced concrete industrial construction, with descriptions of the systems of construction.

PHILADELPHIA GEAR WORKS, INC., Seventh and Cherry Sts., Philadelphia, Pa. New catalogue containing all necessary information relative to the stock gears of the company, and giving rules and tables for figuring gears.

PATTERSON, GOTTFRIED & HUNTER, Ltd., New York. Catalogue of 260 pages on blacksmiths' tools. While the catalogue pertains essentially to blacksmiths' tools, it also contains information of general interest to machinists and repair men as well. When writing for a copy ask for catalogue 119.

WELLS BROS. CO., Greenfield, Mass. Catalogue No. 22 on screw-cutting tools and machinery, containing descriptions and illustrations of screw plates, taps, dies, reamers, gages, bolt cutters and nut tappers, etc. In addition to its regular line of tools here described, the company makes a variety of special tools.

THE CLEVELAND TWIST DRILL CO., Cleveland, O., has issued a set of ready reference cards containing data upon taper shanks, drill list for taps, high-speed steel drills, etc. These sheets are so arranged that they can be hung up and easily referred to. A set will be sent to anyone upon making application.

THE AMERICAN LOCOMOTIVE CO., 111 Broadway, New York, has issued a pamphlet describing a rotary snow plow, giving a brief account of the work done by this type of plow in fighting snow on various railroads. The pamphlet contains a set of rules for the guidance of those operating this type of machine.

BALDWIN LOCOMOTIVE WORKS, Philadelphia, Pa. Pamphlet entitled "The Actual Efficiency of a Modern Locomotive," being No. 60 of this series on locomotive construction and related matters. The subject matter is a paper read by William Penn Evans before the Pacific Railway Club, February 17, 1906.

EXPANDED METAL & CORRUGATED BAR CO., St. Louis, Mo. Catalogue comprising a collection of illustrations showing the work done with the corrugated bar in a variety of structures, some information concerning corrugated bar, and simple formulas and tables for use in designing.

ISRAEL LUDLOW, superintendent of the Aeronautical Bureau, Jamestown Exposition, New York, has sent us a list of the aeronautical competitions which will be held at the Jamestown Exposition at Norfolk, Va., April 26 to November 30, 1907. The list includes twenty-five events and include dirigible balloon competition, flying devices heavier than air, kites, etc.

BANTAM ANTI-FRICTION CO., Bantam, Conn., has issued a new catalogue calling attention to several new ideas relating to roller bearings, some of which may be noted on pages 6, 13, 18, 21, 22, 23 and 24. Reprint of an article on the Mechanical Design of Ball Bearings and Roller Bearings, contributed by W. S. Rogers to the *Engineering Magazine* is also included.

MIAMI VALLEY MACHINE TOOL CO., Dayton, Ohio. Catalogue of the Miami Valley lathe and drills. At the present time the company builds a 13½-inch engine lathe and 12-inch and 14-inch sensitive drills. The size of the lathe and its modern features make it a machine desirable for manual training school work as well as for general manufacturing purposes.

RECORD of Transportation Lines Owned and Operated by the Pennsylvania Railroad for the year ending December 31, 1906. 45 pages, 9 x 12 inches. Published by the Pennsylvania Railroad, Philadelphia, Pa. The record gives the names of the various railways, ferries and canals, and general data regarding same. It includes a large map in colors, showing the ramifications of this enormous transportation system.

AMERICAN LOCOMOTIVE CO., 111 Broadway, New York, has recently issued a pamphlet devoted to the Mogul type of locomotive. This is the seventh of a series being published by the company to include the various standard types of locomotives. It illustrates and describes 25 different designs of the Mogul type built by the American Locomotive Co. for various railroads. These types range in weight from 49,000 to 187,000 pounds. A copy will be sent on request to those interested.

T. R. ALMOND MFG. CO., 85 Washington St., Brooklyn, N. Y. Advertising novelty in the shape of a salesman's advance card, being a folder in which is pasted a photograph of the salesman opposite a "window" cut out of the front page. The frame of the window is the outline of an Almond chuck. This advance sheet is sent by the Almond salesmen to their customers, notifying them of a future visit of the salesman to their place.

THE WHITMAN & BARNES MFG. CO., Chicago, Ill. Catalogue of "Diamond" high-speed twist drills and reamers made from W. & B. high-speed steel. These drills and reamers are made at the Akron, Ohio, factory of the the company, and cover a wide range of sizes. They are hardened and tempered by special processes which enable the production of tools which give the maximum wearing qualities and still retain the requisite toughness to prevent splitting and breaking. A large stock of high-speed drills is carried, and prompt shipments can be made.

DERRICK'S BRITISH REPORT is the title of a new periodical started in January, 1907, and published by Mr. Paul E. Derrick, 34 Norfolk Street, Strand, London. The price is $10 per year. It is intended to be a careful digest of present British market conditions, and is published in the interest of manufacturers seeking trade extension for goods sold under an advertised name or registered trade mark. The February issue contains a number of able articles reviewing trade conditions at home and abroad.

THE National Export Association of American Manufacturers, Park Row Building, New York. Leaflet explaining the object and methods of this newly-organized association. The export association proposes to secure for its members all the advantages of a systematic cooperation directed towards trade expansion. A European office will be opened in Paris to work with the American office. In this way an American office will be in direct communication with an organization in Europe where the market conditions will be studied at close range. The work of the association will consist in investigating trade, selecting local agents, guaranteeing stock confided to local agents, exhibiting catalogues at its European headquarters, creating a foreign demand, reporting special trade movements, recommending suitable advertising mediums abroad, procuring catalogues, price-lists and samples of European competitors, tending to registration of trade-marks and applications for patents abroad and the various other details that will naturally gravitate to an organization of this character.

MANUFACTURERS' NOTES.

THE STERLING EMERY WHEEL MFG. CO., Tiffin, O., is making a large addition to its factory.

GOLDSCHMIDT-THERMIT CO., New York, has removed its offices to the fourteenth floor of the West Street Building, No. 90 West Street, between Cedar and Albany Streets.

ARMSTRONG BROS. TOOL CO., 113 N. Francisco Ave., Chicago, Ill., has received a medal for its exhibit at the recent international exhibition held at Liege, Belgium, for lathe and planer tool-holders.

CROCKER-WHEELER CO., Ampere, N. J., has established a branch office in Birmingham, Ala., to handle its rapidly increasing Southern business in electric motors and generators.

MACHINERY EXCHANGE, 10 Oliver St., Boston, Mass., is now the headquarters of 30 firms selling machinery, appliances and materials. The exchange has grown rapidly, having more than doubled the number of firms represented within a year.

PITTSBURG AUTOMATIC VISE & TOOL CO., Pittsburg, Pa., recently made a large shipment of vises to the Texas Central Railway Co. The capacity of the company has been increased so that it is in position to fill all orders immediately, regardless of the size or style of vise.

W. GERHARDI WORKS, Lindenscheid, Westphalia, Germany, desires to receive American catalogues, booklets, circulars, reference lists, etc., of all classes of machines and tools, special and automatic machinery of every description, power plant equipment, electrical equipment and of the hardware trades.

THE XYLOTITE PRODUCT CO., Cincinnati, Ohio, formerly manufacturer of fiber pulleys, has discontinued the business, and the machinery has been sold. Mr. Mark Muggeridge, who was general manager of the plant, has taken the position of general superintendent of the Queen City Machine Tool Co., Cincinnati, Ohio.

KRIPS-MASON MACHINE CO., INC., 1636 N. Hutchinson St., Philadelphia, Pa., has established a New York office at 125 West 23d St., with Mr. Edgar A. Wilhelmi as its selling agent. The business of the Krips-Mason Machine Co. is the building of special machinery for making washers and metal specialties.

NUTTER, BARNES & CO., Boston, Mass., are now located at their new factory, 326 A St., where, with increased floor space and a more complete equipment of tools, they expect to be better prepared to meet the increasing demand (which has more than doubled in the past year) for their metal saw cut-off machines and automatic saw sharpeners.

AMERICAN LOCOMOTIVE CO., 111 Broadway, New York, has received the following list of locomotive orders for delivery to foreign countries: Two 8-wheel passenger locomotives for the Canton Hankow Railway, China; three Prairie type tank locomotives for the Yueh Han Railway, China; five Prairie type tank locomotives for the Yokohama Railway of Japan; two 4-wheel type saddle tank locomotives, Government Railway of Guatemala; and three Mallet type locomotives, Central Railway of Brazil.

THE S. OBERMAYER CO., Cincinnati, O., will entertain the Pittsburg Foundrymen's Association in June. A special train will take the guests to the new Obermayer plant at Rillton, Pa. This new plant is the latest addition to the already large manufacturing capacity of the company and makes a total of five plants operated by them for the manufacture of foundry facings and supplies, located as follows: Cincinnati, Chicago, Pittsburg, Larimer, Pa., and Rillton, Pa. Rillton is only a short distance from Pittsburg, in the heart of the Westmoreland district, on the line of the Pennsylvania R. R.

NILES-BEMENT-POND CO., New York, has opened new offices in Chicago on the sixth floor of the Commercial National Bank Building, Clark and Adam Sts. The Pratt & Whitney Co. will abandon its showroom at 46-48 S. Canal St. and will combine its machinery sales department with that of the Niles-Bement-Pond Co. The Pratt & Whitney small tools show room and stock room will be located on the ground floor of the new Plamondon Bldg., Clinton & Monroe Sts., where a complete list of small tools and gages will be carried in stock. Mr. Geo. F. Mills will continue as manager of the Chicago office.

THE PEERLESS RUBBER MFG. CO., 16 Warren St., New York, has broken ground for a large three-story factory building at its already extensive plant at New Durham, N. J. The additional capacity afforded by the new building will give the company one of the largest mechanical rubber plants in the world. There will be installed several new calendering machines, a number of presses for mold work and a new battery of washers, grinders, mixers, etc. The improvements, when completed, will add about 30 per cent to the present capacity.

THE March 28 meeting of the Technical Publicity Association at the Aldine Club, New York, was "house organ" night, the subject being the periodical publications issued by various manufacturing concerns to advertise their products. The editors of the successful house organs issued by a number of the leading manufacturing concerns were present, and several made addresses. In some cases the house organ has taken the place of the advertising in the trade press altogether, and in other papers the trade magazine has been used to supplement regular trade paper advertising.

MODERN MACHINERY & ENGINEERING COMPANY, Cleveland, Ohio, has been incorporated, and has acquired the business as selling agents for the Potter & Johnston Machine Co. and Landis Tool Co., formerly conducted by W. E. Flanders, with offices at 309 Schofield Bldg., and 933 Monadnock Block, Chicago, Ill. Thomas F. Ahern, M.E., who has been manager of the Chicago office for the past two years, and formerly with the Pratt & Whitney Company, is treasurer of the new company. The company has received an order for $150,000 worth of machinery equipment for the new plant of the Rainier Motor Car Co., Detroit, Mich. It is expected that this plant will be in operation by June 15, and that about 600 cars will be turned out in 1908.

THE seventh annual session of the "Summer School for Artisans" of the University of Wisconsin begins June 24 and continues six weeks. Courses of study are offered on engines and boilers, applied electricity, mechanical drawing and machine design, materials of construction, fuels and lubricants, shop work and manual training. The entire laboratory and shop equipment of the College of Engineering is used by the students in the summer school. The requirements for admission are only a working knowledge of English and arithmetic. Further information may be obtained from Mr. Frederick E. Turneaure, Madison, Wis.

THE AMERICAN PULLEY CO., 29th and Bristol Sts., Philadelphia, Pa., has lately completed important additions to its plant. During the past year the factory has been equipped for making pulleys 44, 46 and 48 inches in diameter, from 6 to 16 inches face (diameters and faces varying by 2 inches), so that the total range of sizes which can now be had of this type of pulley is from 6 to 48 inches diameter, and from 2 to 16 inches face, according to diameters. In 1897 the output of the company for the year was 18,000 pulleys from 6 to 24 inches diameter; in 1906 the output was 200,000 pulleys from 6 to 42 inches diameter. An eight-arm pulley has recently been added to the line.

THE AMERICAN LOCOMOTIVE CO., 111 Broadway, New York City, at the coming Jamestown Exhibition will occupy a plot 100 x 250 feet in the southern portion of the grounds on the southeasterly side of Lee's parade grounds. The exhibit will be housed in a building especially

CUT OUT ON THIS LINE.

CUT OUT ON THIS LINE.

PUNCH PUNCH PUNCH PUNCH PUNCH PUNCH

These operation sheets, covering every class of shop work, will be made a permanent feature of all Editions, and will appear every month. They may be cut along the top and margin lines for filing and binding. Suitable binders of sufficient capacity to hold four years' issues will be supplied by The Industrial Press for 25 cents each, including postage.

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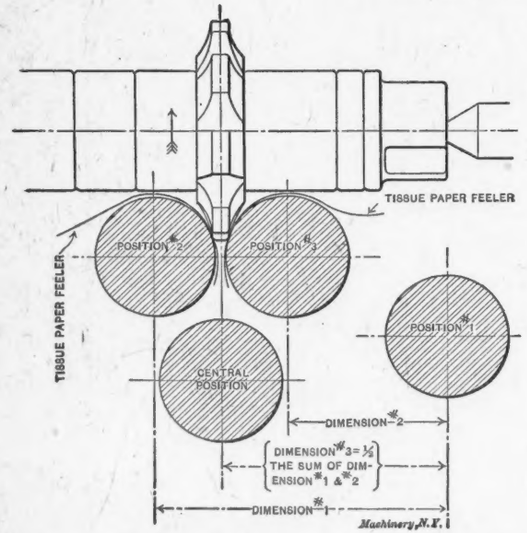
SHOP OPERATION SHEET NO. 1.

Ralph E. Flanders. MACHINERY, May, 1907.



Cutting a 4-Pitch 30-Tooth Spur Gear in the Milling Machine—Centering the Cutter.

1. Clamp a 4-pitch No. 4 cutter on the arbor. Tighten bearings of knee, saddle and table until they move stiffly, but yet evenly. Place a true arbor between the dividing head and foot-stock centers. Bring the arbor to any convenient Position No. 1 as shown in the cut, outside of and below the cutter.

2. Set the graduated dial of the cross-feed screw to zero.

3. Move the arbor to Position No. 2, so that the cutter will just barely "bite" a thin tissue paper "feeler" between its cutting edge and the arbor.

4. Set the elevating screw dial at zero and note on the cross dial the distance moved in changing from Position No. 1 to Position No. 2. Call this amount Dimension No. 1.

5. Lowering the arbor again, return to the Position No. 1 horizontally, the vertical position not being particular. Raise the table until the elevating screw dial marks zero at the same vertical height as Position No. 2. Move the arbor inward until the cutter bites the tissue paper feeler as before. Note on the cross-feed dial the distance by which the arbor is moved horizontally from Position No. 1 to Position No. 3, and call this amount Dimension No. 2, as shown in the sketch.

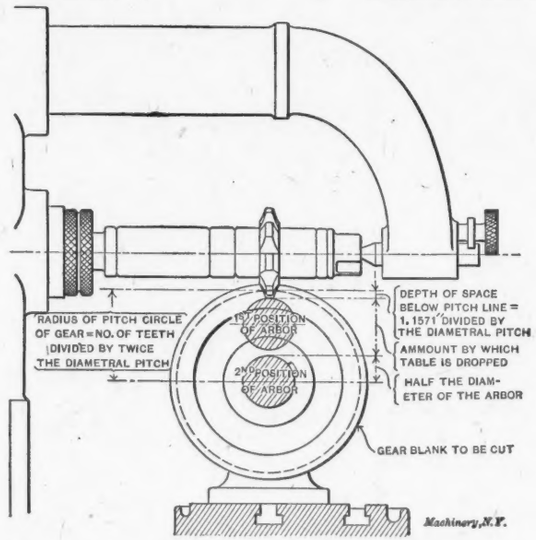
6. Add together Dimensions No. 1 and No. 2, and divide the sum by 2. The result will be Dimension No. 3, shown in the sketch.

7. Return the arbor to Position No. 1, so far as the horizontal location is concerned; drop it well below the reach of the cutter, and move it in toward the column by an amount equal to dimension No. 3. This is the central position.

Note.—All dial readings must be taken at the end of inward or upward movements, to avoid errors due to backlash.

SHOP OPERATION SHEET NO. 2.

Ralph E. Flanders. MACHINERY, May, 1907.


RADIUS OF PITCH CIRCLE OF GEAR = NO. OF TEETH DIVIDED BY TWICE THE DIAMETRAL PITCH
1ST POSITION OF ARBOR
2ND POSITION OF ARBOR
DEPTH OF SPACE BELOW PITCH LINE = 1.1571 DIVIDED BY THE DIAMETRAL PITCH
AMMOUNT BY WHICH TABLE IS DROPPED
HALF THE DIAMETER OF THE ARBOR
GEAR BLANK TO BE CUT
Machinery, N.Y.

Cutting a 4-Pitch 30-Tooth Spur Gear in the Milling Machine—Setting the Cutter to the Proper Depth.

1. Place a true arbor between the centers.

2. Bring the arbor up to the revolving cutter until tissue paper feeler is "bitten" between the cutter and the arbor.

3. Set the graduated dial for the vertical movement at zero.

4. Divide 1.1571 by the diametral pitch to find the depth of space below the pitch line: $1.1571 \div 4 = 0.2893$ inch.

5. Add to this, half the diameter of the arbor. For a 2-inch arbor we have $2 \div 2 = 1$ inch, and $1 + 0.2893 = 1.2893$ inch.

6. Find the radius of the pitch circle of the gear by dividing the number of teeth by twice the diametral pitch, thus: $30 \div (2 \times 4) = 3.75$ inches.

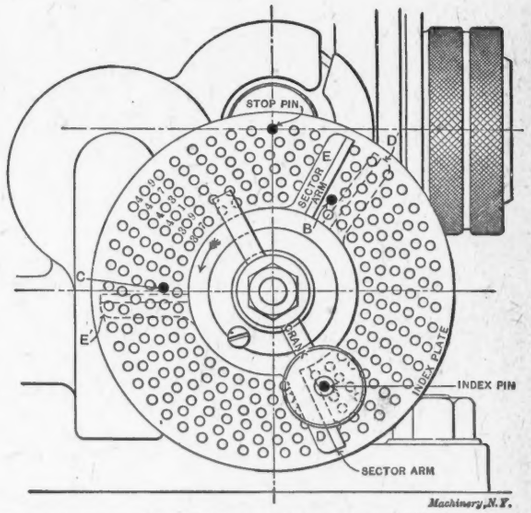
7. Subtract the distance obtained in Step 5 from that found in Step 6, thus: $3.75 - 1.2893 = 2.4607$ inches.

8. Reading the dial lower the table from the first position the amount found in Step 7. To avoid backlash, lower the table further than is necessary, and bring it up again to the proper position. The machine is now set to cut a tooth of the correct depth.

Note.—If the cutter is too thick, or too thin, or if it runs out, the teeth will be too thick or too thin, as the case may be. But if the blank has the proper outside diameter (found by adding 2 to the number of teeth and dividing by the diametral pitch), the proper thickness of tooth may be gaged by suitable fixed gages, or by the B. & S. gear tooth caliper. If these are not at hand, or if the outside diameter is not accurate, the gear may be tried in place with its mating gear and the fit noted. The setting may then have to be altered from that calculated.

SHOP OPERATION SHEET NO. 3.

Ralph E. Flanders. MACHINERY, May, 1907.



Cutting a 4-Pitch 30-Tooth Spur Gear in the Milling Machine—Indexing.

1. From the table furnished with the machine, find the indexing required. Say that 30 teeth require 1 complete turn and 13 holes more in the 39 circle.

2. Lock the dial with the stop pin, and adjust the index pin to the circle of holes called for in the table—39 in this case.

3. Adjust sector arms *D* and *E* until they include between their beveled edges the number of extra holes required plus one. Here the arms include $13 + 1 = 14$ holes in the 39 circle.

4. Indexing may be done in either direction. Give the crank a portion of a turn to take up the back lash, and drop the pin in one of the holes. Bring up behind it the beveled edge of the sector arm *D*.

5. Take the required cut.

6. Withdraw the index pin and turn the crank in the direction of the indexing by the number of turns given in the table (one in this case), then continue until the pin enters the last index hole *B* before the second sector arm *E*.

7. Rotate the sector arms until arm *D* has been moved to *D'*, behind the index pin again. Arm *E* is then at *E'* in a position to locate the next stopping point, *C*, for the pin.

8. Take the second cut, and continue the indexing as before.

Note.—It is well to nick the blank before cutting the full depth to make sure that there is no error in the indexing. To do this, touch the edge of the rim with the revolving cutter. Index and repeat in turn for each tooth of the gear. When the starting point is again reached, carefully observe the operation to see if the cutter strikes in exactly the same place. If it does, and if the number of nicks thus made is equal to the number of teeth desired, the indexing is correct.